REPORT BY THE U.S.

General Accounting Office

Followup On Use Of Numerically Controlled Equipment To Improve Defense Plant Productivity

Two prior GAO reports analyzed the use of numerically controlled equipment--controlled automatically by computers or punched tape--and made a number of recommendations to coordinate and improve the use of this equipment in the Department of Defense.

However, the Department has not taken adequate action even though it promised to do so.

This report illustrates the continuing disparity and problems among service activities and recommends that the Department implement earlier recommendations.

LCD-78-427
JANUARY 17, 1979

UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

LOGISTICS AND COMMUNICATIONS DIVISION

B-140389

The Honorable Harold Brown
The Secretary of Defense

Dear Mr. Secretary:

This is our third report on the use of numerically controlled equipment in the Department of Defense's industrial plants.

Two prior reports, "Numerically Controlled Industrial Equipment: Progress and Problems" (B-140389, Sept. 24, 1974) and "Use of Numerically Controlled Equipment Can Increase Productivity in Defense Plants" (LCD-75-415, June 26, 1975), addressed the need for the Department to take a more active role in implementing the use of such equipment in Defense plants.

Little action was taken on our previous recommendations, and numerous opportunities remain to improve productivity in the Defense environment by properly using and managing numerically controlled equipment.

This report contains recommendations to you. As you know, section 236 of the Legislative Reorganization Act of 1970 requires the head of a Federal agency to submit a written statement on actions taken on our recommendations to the House Committee on Government Operations and the Senate Committee on Governmental Affairs not later than 60 days after the date of the report and to the House and Senate Committees on Appropriations with the agency's first request for appropriations made more than 60 days after the date of the report.

Copies of this report are being sent to (1) the Senate Committees on Appropriations, Armed Services, and Governmental Affairs, (2) the House Committees on Appropriations, Armed Services, and Government Operations, and (3) the Secretaries of the Army, the Navy, and the Air Force.

Sincerely yours,

R. W. Gutmann

R. W. Gutmann
Director

U.S. GENERAL ACCOUNTING OFFICE REPORT TO THE SECRETARY OF DEFENSE

FOLLOWUP ON USE OF NUMERICALLY CONTROLLED EQUIPMENT TO IMPROVE DEFENSE PLANT PRODUCTIVITY

D I G E S T

The Department of Defense owns $336 million worth of numerically controlled equipment, such as drills, mills, lathes, and machining centers. This equipment--controlled automatically by computers or punched tape--is particularly expensive and complex. Although conventional equipment is more appropriate for many applications, numerically controlled equipment offers increases in productivity and savings--particularly for a small lot production. Also, depending on its management and application, numerically controlled equipment can improve Defense plant surge capability for emergencies.

On the other hand, unless management closely monitors this capability, it may not function as intended during a mobilization buildup. Some factors that are crucial are adequate computer support, qualified programers, and availability of the programs.

Two prior GAO audits analyzed Defense-owned numerically controlled equipment. The reports 1/ listed problems in identifying a need for such equipment, planning for numerical control as a total production system, managing the equipment, and using followup assessment systems. These conditions suggested Defense needed to take a more active role.

1/"Numerically Controlled Industrial Equipment: Progress and Problems," B-140389, September 24, 1974. (See app. I.)

"Use of Numerically Controlled Equipment Can Increase Productivity in Defense Plants," LCD-75-415, June 26, 1975. (See app. II.)

LCD-78-427

Defense had agreed to (1) establish a Tri-Service Numerical Control Management Committee to pursue the problems identified, (2) study the feasibility of reducing spare parts inventory levels through tape data package storage, (3) consider work interchange between activities to increase efficiency, and (4) continue efforts to coordinate and work with other agencies to promote the use of advanced production technology. (See p. 17.)

GAO made this review to assess what Defense had done to improve its use and management of numerically controlled equipment.

DEFENSE AND INDIVIDUAL SERVICE ACTIONS

Defense did establish a Tri-Service Numerical Control Committee; however, its activities dwindled and little was achieved. In February 1975 Defense stated the Committee had drafted an instruction on numerically controlled equipment which was to be issued shortly. But it had not been issued as of October 1978. Further, there have been no major attempts to (1) reduce inventory levels of parts, (2) enforce work interchange, or (3) establish cooperative numerical control working relationships with other agencies. (See p. 18.)

Other agencies and Defense components began independent actions aimed at many issues covered in GAO's earlier reports. However, coordination could preclude the need for individual components to develop independent procedures and policies for managing and using numerically controlled equipment. (See p. 20.)

ACTIVITY-LEVEL OPERATIONS

GAO briefly examined selected subjects covered in its earlier reports at several activities and found:

--Standardization continues to be a problem and is approached differently by different commands and activities.

--Work interchange between activities has not occurred except for a few work orders. At GAO's suggestion, two activities are now working toward exchanging work to relieve a heavy workload at one activity and improve utilization at another activity.

--Air Force activities employ formal work-mix study techniques to identify equipment needs, whereas others buy equipment because of production bottlenecks or deteriorated machines, sometimes without critically evaluating numerically controlled machines.

--Management information systems are extremely diverse in terms of usage categories recorded, and some systems are inaccurate and inadequate. Likewise, followup systems to test whether projected justification benefits are actually realized are diverse, inadequate, or nonexistent.

--Systems for workloading parts onto conventional or numerically controlled machines need improvement.

--Most shops have given priority to numerically controlled machine repair part acquisition. However, procedures could still be more streamlined.

Beyond the subjects analyzed, GAO observed or was told of many other problems which hamper the effectiveness of activities' numerically controlled equipment operations.

As a result of GAO's followup, Defense is again requesting service comments on the latest numerical control directive. Currently the directive delegates to the services and Defense components the responsibilities of improving the matters discusssed in GAO's earlier reports. GAO continues to believe that many problems are beyond the ability of individual services to resolve and more direction is needed.

RECOMMENDATIONS

The Secretary of Defense should:

--Activate a DOD or combined-service group or assign to an existing group the responsibility to provide overall technical and policy direction and coordination for numerically controlled equipment. The group should periodically provide status reports of its progress and problems.

The Secretary should require the group to address the areas suggested in our 1974 report, which were to:

--Develop and enforce a policy encouraging interservice standardization for both numerically controlled hardware and software.

--Improve the systems for identifying opportunities for numerical control. Adequate workmix studies should be made, and numerically controlled equipment should be considered when conventional equipment is requested.

--Improve the planning for numerically controlled machine purchases by developing guidelines on planning for numerical control as a total production system.

--Investigate the establishment of a Government-wide inventory of numerically controlled repair parts for numerically controlled equipment and require activities to consider that inventory before buying complete spare parts kits.

--Clarify the policies on multishift use and reserve capacity of numerically controlled equipment to obtain maximum use of such equipment.

--Improve the management of numerical control. The activities need (1) better management information on machine utilization, (2) more training for numerical

control, (3) criteria and procedures, including cost comparisons, for determining what work should be done on numerically controlled equipment, (4) adequate preventive maintenance programs, (5) authority to give priority to procuring needed repair parts, and (6) better systems for exchanging work between similar activities and between services.

--Study the possibilities of reducing inventories through numerical control and of exchanging numerical control data packages.

--Establish uniform guidelines on developing followup systems which will more accurately disclose the true savings and costs of numerically controlled equipment.

Further, as covered in GAO's 1975 report, GAO again recommends that the Secretary:

--Require that no justifications for new machines be approved unless the activity has adequately considered using the capacities of other activities in the geographical area.

--Insure that the necessary computer support and programers are available to meet mobilization requirements.

AGENCY COMMENTS

DOD and service officials agreed there is a need to have some type of interservice group or function to share ideas, reduce duplication, and work on mutual problems. The officials promised positive actions but had not decided on how a group would be organized or what it would address. Therefore, GAO plans future inquiries into these matters.

Contents

ABBREVIATIONS

DOD	Department of Defense
GAO	General Accounting Office
NC	numerically controlled/numerical controlled

CHAPTER 1

INTRODUCTION

The Department of Defense (DOD) components maintain a large, complex industrial base to meet contingency and war mission needs and provide expansion to meet prolonged wartime mobilization requirements. In peacetime the base is used to maintain, repair, and overhaul weapon systems and produce munitions and other war materials. Costs for fulfilling these requirements are enormous and are rising. Numerically controlled (NC) equipment, as discussed in this and prior reports, 1/ offers benefits--if managed properly--in terms of meeting mobilization requirements and achieving efficiencies and economies.

This report describes the status of DOD's NC activities and illustrates that a good deal more must be done for DOD to realize the full benefits of NC equipment in its (1) Government-owned, Government-operated facilities and (2) Government-owned, contractor-operated facilities and to indirectly realize benefits from the contractor-owned, contractor-operated plants.

RESPONSIBILITIES FOR EQUIPMENT MANAGEMENT

The Secretary of Defense is responsible for planning the procurement and production of military equipment and supplies needed to fulfill emergency requirements and for maintaining an adequate mobilization production base. The DOD Industrial Preparedness Program is the basic vehicle for carrying out these responsibilities. This program has three primary aspects (1) modernizing and expanding Defense-owned production facilities through new investments, (2) planning with industry to retain privately owned production facilities, and (3) retaining existing Defense-owned facilities and equipment to meet mobilization needs.

Both the military services and the Defense Industrial Plant Equipment Center, Defense Logistics Agency, 2/ have management responsibilities for Defense-owned industrial

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1/Digests of prior reports are included as appendixes I and II.

2/Name changed from Defense Supply Agency.

plant equipment. The services' responsibilities include determining equipment requirements, reporting the status of equipment (i.e., actively being used or in an idle condition) to the Center, and maintaining equipment in their possession. The Center's responsibilities include (1) maintaining a central record of all Defense-owned equipment, (2) acting as a clearinghouse to obtain optimum reuse of equipment, and (3) managing a general equipment reserve for possible mobilization requirements.

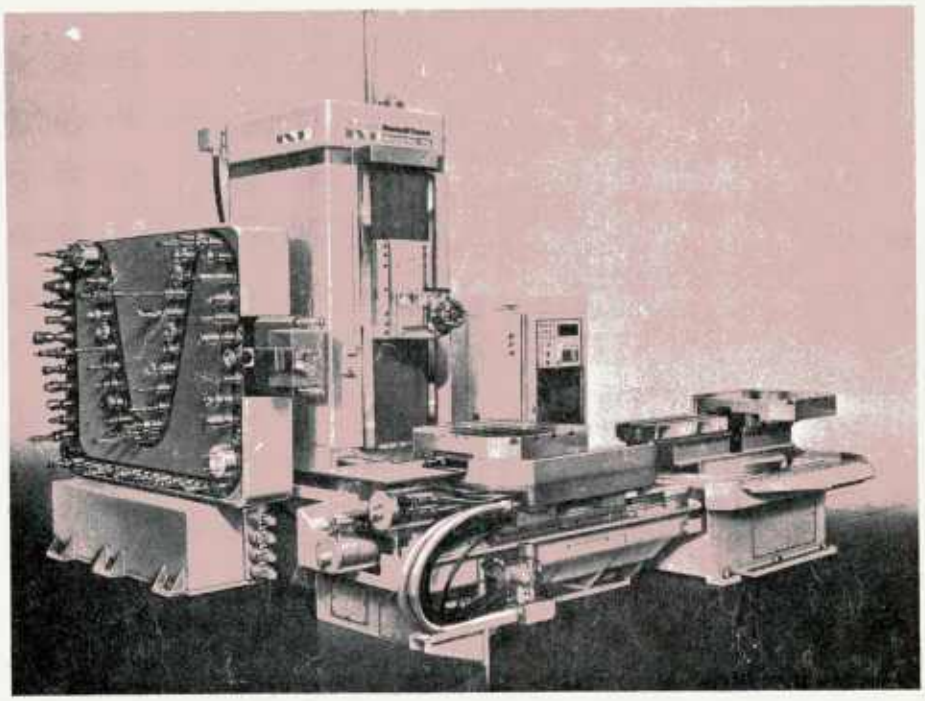
DESCRIPTION OF NC

In a broad sense an NC system 1/ is machinery controlled automatically by coded instructions. An NC system has two basic elements: (1) The machine which does the work and (2) an electronic control unit which directs the machine's motions and operations. Some machines operate directly from computers, but most get instructions in the form of punched tape.

Most NC equipment is used for metalworking, but its uses include a wide variety of other manufacturing operations. Most of the machines in use are drills, mills, lathes, punches, and machining centers. Photographs of some NC machines are shown on pages 3 and 4.

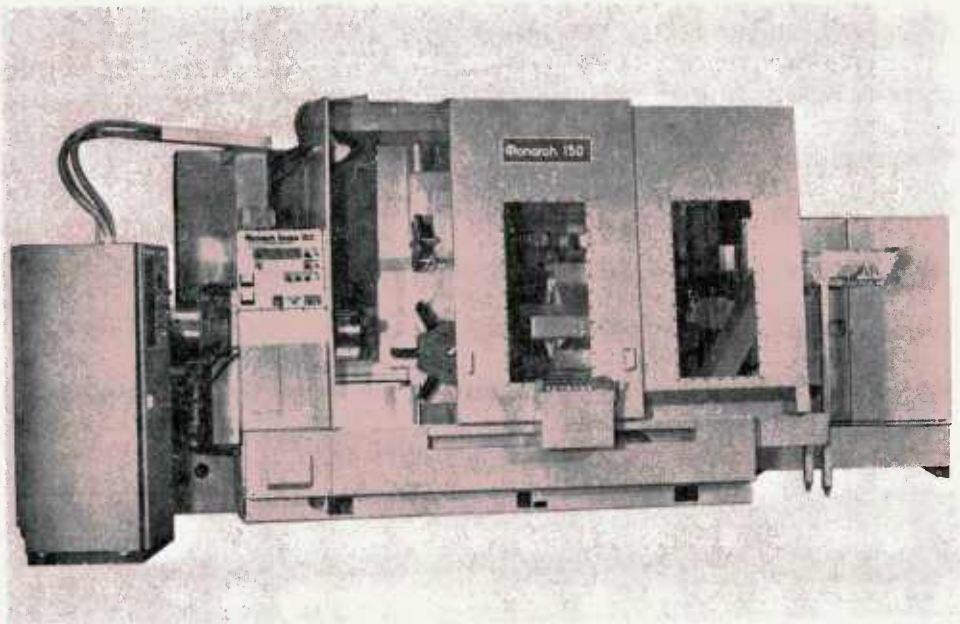
A computer assists in the programing function primarily by making calculations to position and control the cutter along the paths necessary to accurately machine the part. A postprocessor (special computer program) converts general cutter-path instructions into punched-tape codes peculiar to the specific NC machine. The operator places the fixture on the machine tool, loads the material into the fixture, places the cutter in the spindle and over the target, places the tape in the control unit, and starts the operation. The control unit then assumes command and guides the cutter in its predetermined path. The first tryout of the tooling and tape usually reveals errors or a need for adjustments. After errors are corrected, production is consecutive. The complete process is illustrated on page 5 .

1/"Numerical control," as used in this report, is to be considered a generic term and includes derivatives such as computer numerical control (CNC) and direct numerical control (DNC). (See p. 6.)



(Courtesy of Kearney & Trecker Corp.)

FOUR-AXIS COMPUTER NUMERICAL CONTROL MACHINING CENTER. ITS 68 CUTTING TOOLS ARE CHANGED AUTOMATICALLY AS ARE THE PARTS AFTER BEING MACHINED. COST ABOUT $300,000.

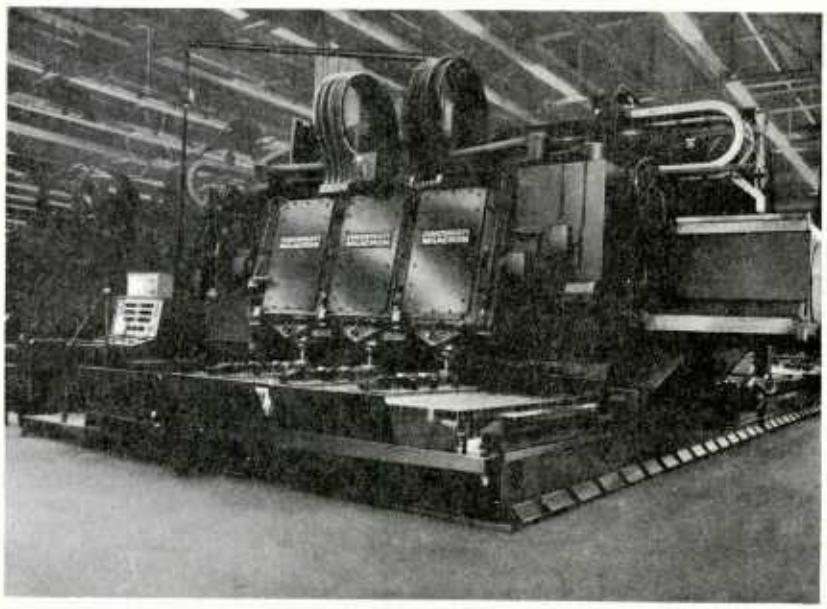


(Courtesy of Monarch Machine Tool Company)

VERTICAL BED CHUCKER AND SHAFT TURNING MACHINE WITH CONVEYER CHIP COLLECTING SYSTEM. ITS TWO – TURRET ARRANGEMENT CAN HANDLE INTERNAL BORING AND EXTERNAL TURNING CUTS AUTOMATICALLY. COST ABOUT $200,000.

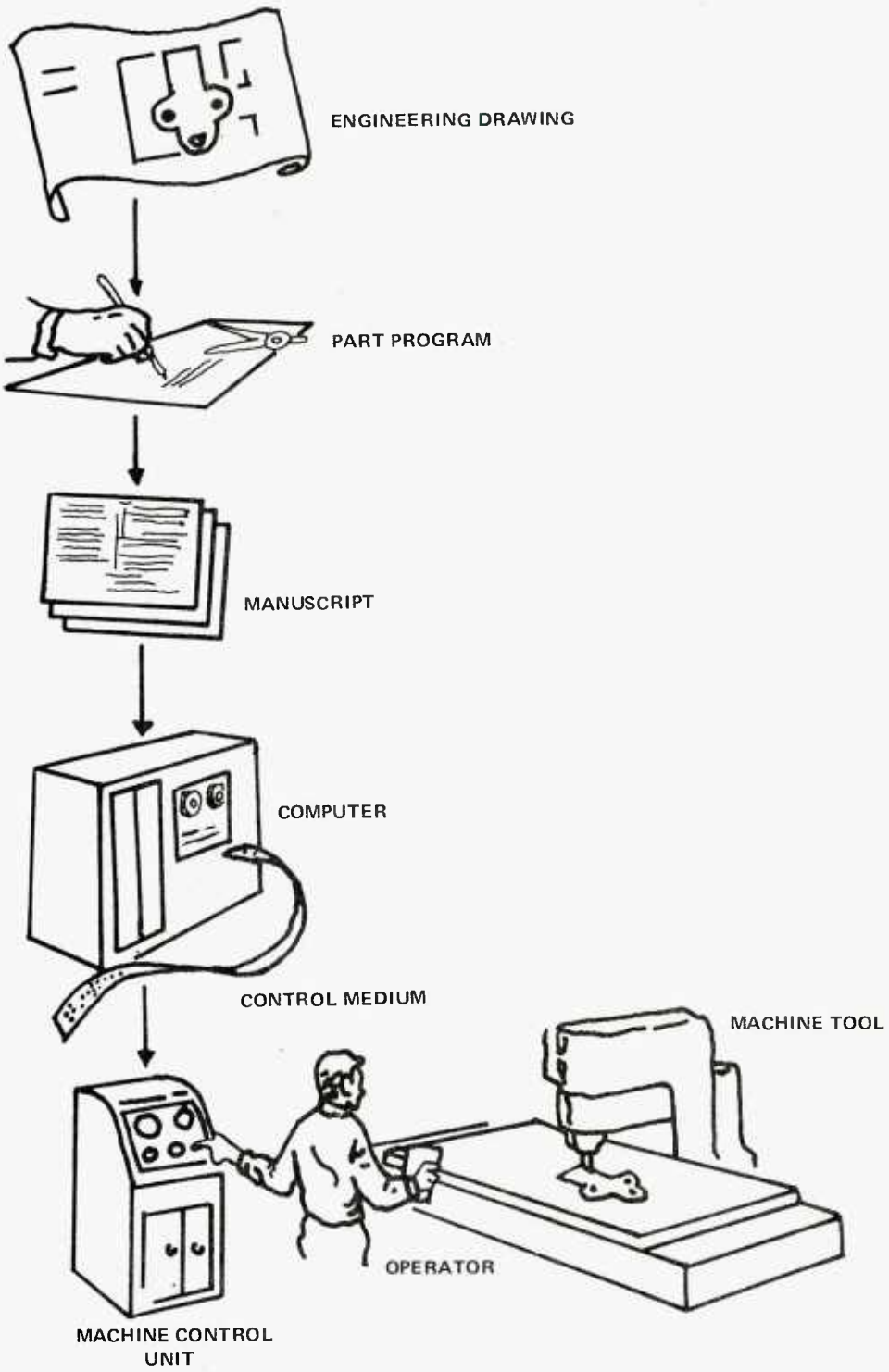
(Courtesy Of Bridgeport Machines)

LOW-COST, THREE-AXIS MILLING MACHINE. AUTOMATIC CYCLING AND ATTACHMENTS ENABLE THE MACHINE TO PERFORM DRILLING, TAPPING AND BORING OPERATIONS. COST ABOUT $40,000.



(Courtesy of Cincinnati Milacron)

LARGE (90-FOOT) PROFILE MILLING MACHINE EQUIPPED WITH THREE FIVE-AXIS HEADS ON EACH OF TWO GANTRIES. THE MACHINE IS CAPABLE OF AUTOMATICALLY PRODUCING SIX LARGE AIRFRAME PARTS SIMULTANEOUSLY. INSTRUCTIONS ARE TRANSMITTED FROM A CENTRAL COMPUTER THROUGH A DIRECT NUMERICAL CONTROL SYSTEM. COST ABOUT $1,700,000.


ENGINEERING DRAWING
PART PROGRAM
MANUSCRIPT
COMPUTER
CONTROL MEDIUM
MACHINE TOOL
OPERATOR
MACHINE CONTROL UNIT

Numerical control, like most technologies, is an advancing and evolutionary process. Hard-wired systems, which were universal a few years ago, have given way to minicomputers and microprocessors (computer numerical control) which are less costly and more reliable and have greater capability. Direct numerical control, wherein a number of machines are operated by a single computer, and distributed numerical control, which involves the communication of a complete program from a large computer to a computer numerical control system, are becoming more popular. Further, computer graphic systems for part programing and shop management information systems are progressing and are expected to increase productivity and reduce manufacturing costs substantially.

While conventional metalworking equipment may be more appropriate for longer runs of simple parts or for intermittent or ancillary operations, NC machines, when used under the proper circumstances and applications (such as with short runs of the more complex parts), can manufacture superior and more economical products than can conventional ones. NC machines operate best in operations requiring the machining of parts in small lots or batches where setup costs are high, because the economic break-even point for small lots comes much earlier with NC machines than with conventional ones. Also some very complex jobs can be done only on NC machines.

Increases in productivity from using NC machines vary with the machines and the parts to be produced. On some parts, productivity increase ratios of 10 to 1 over conventional machines are not uncommon. But NC machines are expensive and complex, so they require special management. Their control systems contain complex electronic components, compounding maintenance problems. Also programers, operators, and other personnel need special training.

GROWTH AND INVESTMENT IN NC EQUIPMENT

Since our prior reports, procurements of NC machines have continued to increase. During the past 5 years, NC machine shipments totaled $2.2 billion and accounted for 50.9 percent of the total metalworking machine shipments when considering NC equipment which has conventional counterparts. The graph on page 8 depicts the growth of NC machine installations.

DOD is probably the largest purchaser of items produced by privately owned NC machines and is a major user of NC

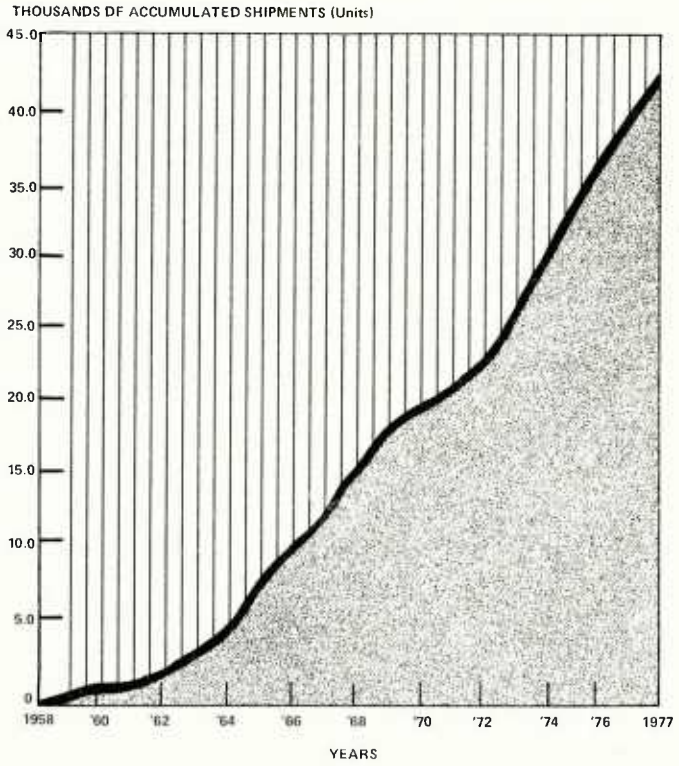
equipment. On December 31, 1977, DOD had an investment in all types of industrial equipment of $6 billion. This includes $2.1 billion of cutting, forming, and other metalworking equipment. On June 30, 1978, DOD owned 2,000 items of NC equipment costing $335.7 million, an increase of $35.4 million in the past 5 years. The chart on page 8 depicts DOD's NC equipment purchases compared with its total metalworking equipment purchases. 1/

In addition, the Department of Energy 2/ had about 470 units costing $48 million and the National Aeronautics and Space Administration had 66 units costing $9.1 million.

1/In this analysis the comparison includes all machining centers, boring machines, drilling and tapping machines, grinders, mills, lathes, and punching and shearing machines.

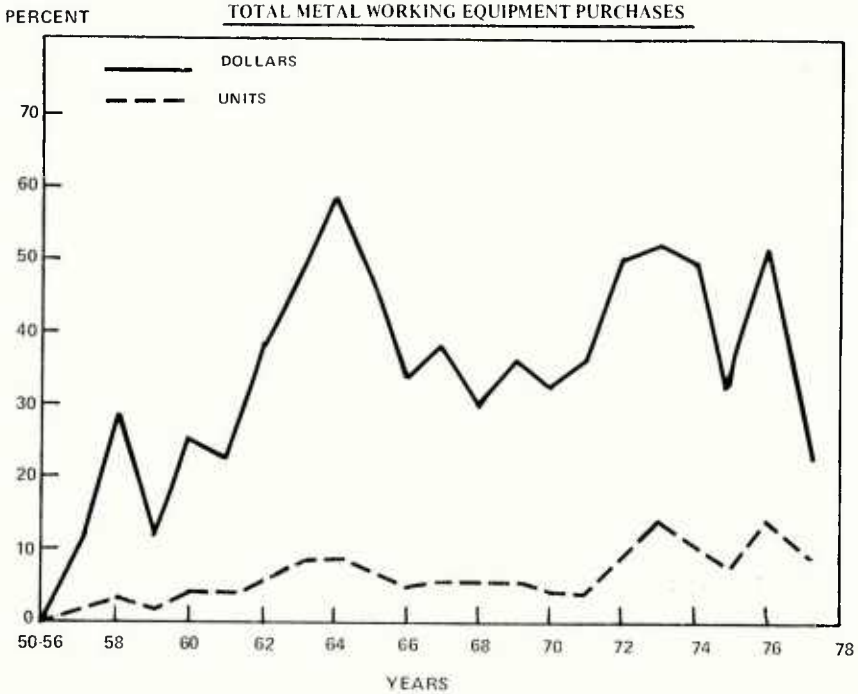
2/Name changed from the Energy Research and Development Administration.

GROWTH OF NC MACHINE TOOL INSTALLATIONS



Source: Department of Commerce statistics

DOD NC MACHINE PURCHASES COMPARED WITH ITS TOTAL METAL WORKING EQUIPMENT PURCHASES



CHAPTER 2

ISSUES TO BE CONSIDERED IN DETERMINING PLANT CAPACITY AND EFFICIENCY

Any decision on whether to use NC or conventional equipment is secondary to the major issue: what DOD's depot capacity should be, based on established requirements and considering commercial and allied resources. Once DOD has properly determined its needed capacity, then the decision to use NC or conventional equipment should be made to develop the most efficient production techniques.

BASIS FOR DOD IN-HOUSE OPERATIONS

Office of Management and Budget Circular A-76 requires the Government to rely on private enterprise for goods and services unless it would be in the national interest for a Government agency to provide the goods and services in-house. In-house operations are permitted when

- --commercial procurement would disrupt or materially delay an agency's program;
- --combat support, military personnel training, or mobilization readiness would be impaired by commercial procurement;
- --a commercial source is not available and cannot be developed in time to provide the product or service when needed and the product or service is not available from another Government agency; or
- --commercial procurement would be much more costly to the Government.

The circular also requires each Government agency to (1) issue instructions to insure that the policy is followed, (2) compile and maintain an inventory of its commercial and industrial activities, and (3) review its activities every 3 years to determine whether in-house operations should be continued.

DOD Directive 4151.1 states that, since maintenance support of military equipment is vital to sustain military power, the services should have adequate programs for maintaining assigned equipment in accordance with military missions. The directive also states that:

"The extent of facility capability and capacity within the Military Departments for depot support of mission essential equipment will be kept to the minimum required to insure a ready and controlled source of technical competence and resources necessary to meet military contingencies. Generally organic depot maintenance capacity will be planned to accomplish no more than 70 percent of the gross mission-essential depot maintenance workload requirements, with a facility capacity loading a minimum rate of 85 percent on a 40-hour week, 1-shift basis."

ESSENTIAL CONDITIONS IN IDENTIFYING REQUIREMENTS FOR IN-HOUSE OPERATIONS

As discussed in a number of our prior reports, 1/ DOD and the services have not adequately defined the extent of their facility capability and capacity needed for military contingencies. The Defense in-house plant capacity should be based on total peacetime and mobilization requirements, less those requirements which private industry and allies will meet. Until total requirements and private industry and allied resources are defined, there is no way of knowing whether the current Defense manpower, facilities, or equipment are more than or less than is needed.

DOD and the services did not in all cases respond to or agree with the issues raised in these reports. However, agreement/acknowledgment did occur on some, as summarized below:

--DOD generally agreed that large dollar savings could be realized by improving the management and operation of the Navy's aircraft overhaul depots. It said that in most instances, the Navy was aware of the problems identified and had corrective actions underway.

--DOD agreed with the need to establish standardized instructions for planning industrial plant equipment needs, for similar commodity areas, so that the services could establish more valid equipment requirements for mobilization production needs.

1/Appendix III summarizes the major elements of these reports concerning DOD plant capacity and capability.

--The Navy agreed, only in part, with the conclusions that the intermediate ship maintenance program operations had evolved without systematic consideration of many basic issues. It stated that since 1975 those activities had received substantial consideration, leading to numerous projects aimed at developing a capability which would satisfy both wartime and peacetime requirements.

--DOD agreed with the recommendations on the need to determine shipyard mobilization needs, prepare contingency plans for staffing, and insure modernization funds are optimally spent. DOD acknowledged that progress in identifying specific mobilization needs had been less than satisfactory and that plans were being developed to take appropriate action with the Navy to develop more detailed mobilization requirements.

After DOD and the services determine their peacetime and mobilization requirements and decide how much of the requirement must be accomplished in-house, after considering private industry and allied capability, they must decide on the most economical and efficient method of accomplishing their workload. This process should include an analysis of NC versus conventional machinery for those operations which could be suitable for numerically controlled equipment.

NC EQUIPMENT'S POTENTIAL IMPACT ON PLANT READINESS AND ECONOMY

Mobilization readiness requires that the U.S. industrial complex--both private and public--be able to meet higher levels of production. The U.S. industrial base could better meet this challenge by using NC equipment where appropriate because, if managed properly, it offers shorter response time and more production than conventional equipment. Depending on the status of its implementation in the Defense environment, NC equipment offers the following attributes regarding readiness:

--NC machine operators generally do not require as much experience as conventional machine operators, so a more ready labor market would be available.

--Numerical control data packages could be acquired from industry and converted to tapes, so Government NC machines could meet higher production requirements in mobilization.

--Parts can be made from stored tapes to respond quickly.

--New parts can be set up more quickly because NC machines often do not require special fixtures.

--NC machines can produce parts many times faster than conventional machines because machine functions are controlled automatically.

--Engineering changes to workpieces can be incorporated rapidly by changing the tape instructions.

However, if NC machines are not properly supported with computers and trained personnel, leadtimes can be longer on NC machines than on conventional machines. Also, if an NC machine is doing the work of several conventional machines and breaks down unexpectedly, the loss in productivity is greater.

Those attributes of NC machines discussed above which affect readiness by shortening response time and increasing productivity also affect on the economy and efficiency of operations. NC machines, being more productive than conventional machines, can decrease the number of machines and operators required for equivalent production. Other aspects of NC machine operations may increase efficiency and economy, such as:

--Reduced inventories of spare parts since tapes which can be readily accessed and put into production can be stored instead.

--Reduced inspection costs because parts made on NC machines allow greater accuracy and repeatability.

--Reduced scrap because, after the first part has been successfully machined, the chances of error in machining subsequent parts are greatly decreased.

--Eliminated design and manufacture of special guiding fixtures as is sometimes necessary with conventional machines.

--Reduced parts handling, since NC equipment permits more operations on a single machine with one setup.

However, if NC machines are not appropriate for the work or are not managed and supported to assure sufficient and proper workloads, the operation may not be cost effective.

The following chapters show that (1) DOD has not taken agreed-upon action to improve the management and use of NC equipment, although many DOD components have taken independent actions and (2) the activities and commands have had disparate success in improving upon matters discussed in earlier reports. More coordination and management attention are needed.

CHAPTER 3

LACK OF OVERALL EFFORT TO IMPROVE MANAGEMENT OF NC EQUIPMENT

Although individual service commands and activities have taken action on our prior reports, there has been little overall DOD effort to coordinate the services' use of NC equipment or to further the development of the field.

Two prior reports showed that NC equipment, if managed properly, could be more productive than conventional equipment. DOD agreed and established the Tri-Service NC Management Committee. However, the Committee did not do what DOD had intended it to do.

PRIOR REPORTS' CONCLUSIONS AND RECOMMENDATIONS

In September 1974 we issued a report to the Congress entitled "Numerically Controlled Industrial Equipment: Progress and Problems." This report pointed out that although DOD had taken an early role in advancing NC equipment, it had failed to take full advantage of this technology and was not properly managing the NC equipment that it did have. In addition, the services had various problems, many of which appeared to be beyond the capability of individual activities to correct. At service activities visited we had noted that:

--Most activities did not have good systems for finding opportunities for NC equipment to economically replace conventional equipment. Use of NC equipment was usually prompted when conventional equipment broke down or new workloads were anticipated. Also much conventional equipment was on order. Staffing did not appear adequate to do workmix studies to identify the more economical production technique.

--The planning process for specific machines could be improved. NC equipment should be planned for as a total package by considering computer support; organizational responsibilities; adequate numbers of trained personnel to program, operate, and maintain the equipment; contents of spare parts kits; and prompt installations. Also the planning for NC equipment should include adequate justification documents. Justifications we examined did not seem to include all costs and benefits of NC equipment and were not always accurate.

--Many aspects of managing NC equipment needed further attention because proper management can make the difference between a quick payback and a loss. Although the extent to which NC equipment is used is not an exacting measure of productivity, making greater use of it should improve investment returns. In our opinion, use was less than it could be because of lack of criteria for what work should be done on NC equipment, unclear policies on the number of shifts NC equipment should be used, inadequate preventive maintenance programs, delays in getting repair parts, and lack of work exchange among activities. Some indirect benefits of NC equipment also were not being achieved; the activities had no programs to reduce stocks of spare parts; tape or program exchanges were not working; and higher skilled operators than may be needed were being used. In addition, management did not always have adequate use data.

--The activities did not always have adequate follow-up systems to help determine future NC equipment needs and to identify management actions needed to increase productivity. Most activities made some attempts to followup on the actual benefits of NC equipment, but the data did not seem adequate for management to decide whether investments were sound or to pinpoint problem areas. Also the emphasis on the need for such data seemed to vary among the activities.

These conditions suggested that DOD needed to take a more coordinated and active role in numerical control. Therefore, we recommended that the Secretary of Defense establish a central DOD group to provide guidance on NC to the service activities and their contractors and to serve as an information clearinghouse and focal point for planning and management. We stated the group could help develop NC's full potential by encouraging and coordinating research and by working toward industry standardization. Specifically, we stated the group should:

--Develop and enforce a policy encouraging inter-service standardization for both NC hardware and software.

--Improve the systems for identifying opportunities for NC equipment. Workmix studies should be made, and NC equipment should be considered when large amounts of conventional equipment are requested.

--Improve the planning for NC machine purchases by developing guidelines on planning for NC as a total production system. In addition, perhaps higher command levels should give more input to preparing accurate justification documents.

--Establish a Government-wide inventory of NC spare parts and require activities to consider that inventory when they procure new machines.

--Clarify the policies on multishift use and reserve capacity of NC equipment to obtain maximum use of such equipment. More indepth management information on use is also needed.

--Improve the management of NC machines. The activities need (1) more training on NC equipment, (2) criteria and procedures, including cost comparisons, for determining what work should be done on NC equipment, (3) adequate preventive maintenance programs, (4) authority to give priority to procuring needed repair parts, and (5) better systems for exchanging work between similar activities and between services.

--Study the possibilities of reducing inventories through NC and of exchanging NC data packages.

--Establish uniform guidelines on developing follow-up systems which will more accurately disclose the true savings and costs of NC equipment.

We also recommended that the Secretary of Defense (1) work with the General Services Administration, the Department of Energy, and other Federal agencies having responsibilities for and interest in the future of NC and (2) consider to what extent DOD should sponsor research and development in the numerical control field.

In a June 1975 report entitled "Use of Numerically Controlled Equipment Can Increase Productivity in Defense Plants," we stated that the benefits of NC equipment were not being fully realized by DOD. Also the possible cost savings and the ability to meet mobilization requirements had been less than planned. We recommended that the Secretary of Defense require that:

--All onhand NC equipment be adequately considered before new machines are approved.

--The necessary computer support and programers be available to meet mobilization requirements.

--Workmix studies be done to identify cost-effective investments in NC machines.

COMMENTS ON PRIOR REPORTS

Department of Defense

Defense agreed that better management and use of Defense-owned production equipment was needed. Specific items of agreement/action are summarized below.

Establishment of a Tri-Service NC Management Committee

In response to our 1974 report, DOD planned to establish this Committee to develop improvements in managing and using Defense-owned NC production equipment and its application to Defense production. This Committee also was supposed to devote its attention to the equipment/software standardization aspect where feasible. Use of NC tools in Defense-owned plants, their maintenance, and personnel training were to be examined, and corrections to existing regulations were to be made where appropriate.

In response to our 1975 report, DOD stated it had established the Tri-Service Committee, which was looking at resolving problems identified in both reports. It was further mentioned that the Committee had prepared, in February 1975, a draft DOD Instruction 4215.xx, "Management of Numerically Controlled Industrial Plant Equipment," which, when implemented, would be a major step toward improving the management of NC resources. Defense also mentioned that the Committee would continue in its efforts to improve DOD's management of numerical control.

Study of inventory reduction through numerical control

Defense stated that our suggestion that current DOD spare parts stockage policies for its weapons be reevaluated to more fully recognize numercial control's capability to reduce preproduction leadtimes would be studied. DOD acknowledged that instances might exist where the procurement of insurance-type spares could be reduced, provided the effective exchange and prompt availability of computer tapes and supporting NC tools could be demonstrated as cost effective.

Work interchange between activities

DOD believed our recommendation concerning arrangements for using other activities' unused capacities before requesting additional in-house machining capacities had merit and stated it had made every attempt to achieve that goal. But the lack of hardware and software standardization had precluded private industry and/or the Government from achieving this goal. The Tri-Service NC Committee was to look at this problem, and with the implementation of its new instruction, it hoped to make inroads toward eventual realization of this concept.

Establishment of cooperative relationships with industry and other agencies

Regarding our concern that DOD had not continued its earlier major role in the NC field, DOD noted that its early effort had been intended to only "prime the pump" and to demonstrate to private industry the benefits that could be realized through use of NC machines. DOD pointed out that, as evidenced by private industry's greatly increased procurements, this effort had been successful. DOD acknowledged that the effective application of numerical control was a national matter in which it had a significant, but nonetheless corollary, interest and stated it was working with industry associations, educational institutions, and other Government agencies.

Other agencies' responses

Copies of our draft 1974 and 1975 reports were submitted for comment to the General Services Administration. Our 1975 report was submitted to the Department of Energy and the National Aeronautics and Space Administration. These agencies generally agreed that the reports were timely and presented ways to increase productivity and agreed with the need for a cooperative effort.

DOD AND SERVICE ACTIONS SINCE OUR EARLIER REPORTS

The draft DOD instruction on management of NC equipment, which was written in 1975, had not been issued as of October. Further there have been no actions to study the potential of inventory reduction through numerical control, improve work interchange, or establish cooperative numerical control working relationships with other agencies. The Tri-Service Committee was active at one time, but its activities dwindled due to other priorities and conflicts. However, individual

activities and commands have taken independent actions to improve some of the matters discussed in our prior reports.

Tri-Service Committee activities and plans

The first of several Tri-Service NC Management Committee meetings was held in September 1974; representatives from the Army, the Navy, the Air Force, and the Defense Logistics Agency attended. The Committee drafted the DOD instruction, supported development of a more detailed form for reporting NC machines owned by DOD, supported having Army NC training classes sponsored by DOD, and sponsored a study on uniform job descriptions and training needs of NC personnel. There were no representatives from the Department of Energy, the General Services Administration, the National Aeronautics and Space Administration, or industry organizations.

The Committee emphasized issuing the DOD directive. After the January 1975 meeting, the draft was sent to the services, the Defense Logistics Agency, and various offices in DOD for review and comment. After comments were received a second draft was prepared, which called for the services and/or activities to

--consider NC when selecting equipment that has an NC counterpart,

--use Defense Logistics Agency specifications for hardware when available,

--do followup analyses consistent with existing directives,

--develop 5-year NC plans for each Government owned and operated facility which had four or more pieces of NC equipment,

--develop NC equipment utilization criteria and goals consistent with peacetime and mobilization workloads and considering work exchange between DOD facilities,

--develop and use an NC equipment preventive maintenance program,

--expedite spare parts for inoperable NC machines needed for production, and

--excess NC equipment according to existing regulations.

The draft directive assigns the Defense Logistics Agency the responsibility for planning and coordinating joint efforts of all DOD components in developing the necessary standards, excluding programing languages, to accomplish

> "the objective of routine electronic transmission of machine readable NC IPE industrial plant equipment process planning and control information between facilities for use with few or no changes, on functionally equivalent NC IPE to produce identical components by 1985."

The Air Force was assigned responsibility for planning and coordinating the joint efforts of all DOD components in developing and implementing the necessary programing language standards.

The second draft was submitted through channels in DOD and then was to be sent again to the services and the Defense Logistics Agency. However, until we began our followup work in January 1978, no further actions had been taken toward issuing the directive.

The Chairman and members of the NC Committee stated that the Committee had not done enough. Several reasons were cited. The initial Chairman accepted another position, leaving the job vacant. Eventually his duties were left unassigned within the Production Resources Office, which experienced a personnel reduction from 12 to 3. Additionally he stated other duties of his job took higher priority.

After we began our followup, the Defense Industrial Resources Support Office submitted the draft again through DOD channels for review and in May 1978 sent the draft to the services, the Defense Logistics Agency, and other DOD groups for review and comment by June 22, 1978. 1/

Other DOD component actions

Although the work of the NC Tri-Service Management Committee has been limited, some interagency coordination has occurred through seminars sponsored by the Defense Industrial Plant Equipment Center and through individual initiatives

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1/Extensions were made for receiving comments, and they were not available during our review.

among members of the CAD/CAM (Computer-Aided Design/Computer-Aided Manufacturing) Subcommittee of DOD's Manufacturing Technology Advisory Group. A description of the activities of these two groups plus actions underway or planned by service commands is included in appendix IV.

Neither the Defense Industrial Plant Equipment Center seminars nor the DOD Manufacturing Technology Group were intended to operate at a level to deal effectively with the issues in our prior reports. Further, while the actions of the other DOD components are a step in the right direction, the absence of a coordinated effort could result in duplication and excessive effort. For example, the Naval Sea Systems Command has drafted a policy directive and the Army Depot Systems Command is initiating a study (both aimed at activity-level management of numerical control), whereas the Air Force has already published a comprehensive directive aimed at the same types of issues. Also the North Island Naval Air Rework Facility has recently been cited in a Naval Audit Service report as having problems with identifying parts that should be machined on NC machines, whereas again the Air Force has developed detailed procedures for accomplishing this.

These situations are not meant to single out any particular service, nor are we indicating that the current procedures of one service would suit other services. Rather, the point is that a coordinated effort could preclude the need for individual components to independently develop procedures and policies to deal with the important and often common factors relating to managing and using NC equipment.

CHAPTER 4

STATUS OF SELECTED ACTIVITY LEVEL NC OPERATIONS

We selected for test purposes several subjects in our prior reports noted as problem areas and visited several activities. We found varying degrees of improvement since our earlier studies, and we continue to believe more direction and coordination are needed. The subjects tested and examples of problems/successes among the activities are discussed below.

STANDARDIZATION

As pointed out in our earlier reports, the uniqueness of most NC systems has caused problems which may limit full development of the field. These problems become particularly acute at the activity level. Also, as indicated in the 1974 report, in no way do we propose anything that would restrict competition or innovation, nor do we propose that a particular machine or system builder be selected as a standard. Rather, classes and types of machines should be developed together with specific control system features, tooling, and software requirements.

The primary characteristics of NC systems which vary are:

--Machines. Most companies produce a wide variety of different model machines. Within the same model, there are differences in horsepower, table sizes, feed and speed ranges, spindle sizes, automatic tool changers, etc.

--Control units. Several machine tool companies build control units for their machines, but most subcontract for control units. Subcontractors may update control units although machines may remain the same. Also activities may update control units through retrofitting. Therefore, different control units having varying features may be used for identical machines.

--Computer support. Different activities and contractors buy different computer support. Some use minicomputers, some have terminal hookups with large computers, and some use installation computers without terminals.

--Programing languages. At least 25 different computer part programing systems are available, most of which are proprietary.

--Tooling. Many machines use automatic tool changers which operate from varying identification systems. Also similar kinds of machines may have different toolholders.

As a result of the variations, operations may not be as economical as possible because (1) work cannot readily be exchanged between Government producers or between Government and industry producers, (2) machines cannot be as readily reassigned to different installations, (3) postprocessors are difficult to obtain and implement--many are proprietary--because they have to be designed for the specific machine, control unit, language, and computer, (4) tooling inventories are increased because of the variety of different toolholders and coding arrangements, and (5) training is difficult because programers have to be trained for different languages and types of machines and maintenance training varies for different types of machines and control units.

Some progress has been made toward standardizing certain areas. The words and format of the APT and COMPACT languages are being standardized by the American National Standards Institute, and toolholders and codes have reached de facto standardization through the efforts of large industry users of NC equipment.

As pointed out before, DOD had agreed to give standardization of hardware and software more effort and DOD's draft directive on managing NC equipment assigns the Defense Logistics Agency/Defense Industrial Plant Equipment Center the responsibility for planning and coordinating joint efforts of all DOD components in developing standards, excluding programing languages. However, preliminary discussions with Defense Industrial Plant Equipment Center officials indicate the directive will not bring about any new functions for the center. Any standardization which comes about will occur through the Center's ongoing development of military specifications for equipment which establishes performance and capability parameters based on vendor and customer input. Therefore, the Center believes it will not be required to assume any new role in hardware standardization.

As a step toward more standardization of software, the Air Force has let a contract with the National Bureau of Standards to develop standards for postprocessor software, so that the programing statements are compatible and the same programs can be used for different machines.

DOD activities continue to have problems with their operations caused by lack of standardization and commonality.

Some are trying to develop local solutions. A description by activity follows.

--The Warner Robins Air Logistics Center currently has to deal with six manufacturers of machines and five manufacturers of control units for its eight machines. Warner Robins is attempting to procure only two name brands of control units. However, it has already had two bid protests and expects more. Local officials have estimated a life-cycle cost of $215,000 for each different type of control due to increased costs for training, spare parts, part programing, etc.

--The Norfolk Naval Shipyard has many different types of machines and control units. However, to overcome the problems and expense of different toolholders, the yard is now making special adapters.

--The Norfolk Naval Air Rework Facility, as most other sites, has stated toolholder problems have decreased due to more standardization brought about by the influence of large private users of NC equipment. In addition, the North Island facility has a project underway to set standards for preset tooling, including tool length settings, sizes, and codes. The Norfolk facility is also retrofitting a new Computer Numerical Control unit to an older machining center to achieve commonality with a recently purchased machining center of the same type.

--The Rock Island Army Arsenal has many varying types of machines. It would like fewer types of control units but sees no way to achieve this since it already has a large investment in NC machines and has made few recent buys.

Private plants are not faced with the procurement constraints which Government plants have. The private companies visited were able to select vendors they wanted, usually selecting a brand they determined to be reliable and one that offered good service. One company bought 96 lathes, of which 53 were from 1 manufacturer and 33 from another. Of the company's 29 machining centers, 12 were 1 brand and 11 were another. The companies noted that buying only one or two brands allowed them to stock fewer spare parts and greatly assisted in training and maintenance.

Though Government procurement processes do not allow the degrees of latitude which private companies enjoy,

more might be done within current Government systems, such as making greater use of multibuys or establishing more uniformity in specifications for machines and controls.

Some activities are achieving more commonality because of actions of their parent commands; however, others are not. For example:

--Air Logistic Centers have achieved a degree of standardization because they all use one central computer. The benefits of such a system include having only 35 postprocessors for 70 machines and using only 1 programing language.

--Naval Sea Systems Command activities, unlike the Air Logistic Centers, do not use common programing systems: the Norfolk and Charleston Shipyards use UNIAPT, Long Beach and Philadelphia use APT, and the Louisville Ordnance Station uses COMPACT II. Also computer arrangements vary among the shipyards due to the variety of computers acquired for other purposes and then adapted for NC programing: Norfolk and Charleston use a dedicated minicomputer, Long Beach uses a commercial time-share system, and Philadelphia uses a large Honeywell computer. Further, except in one instance for drills, the shipyards have not used multibuys to achieve commonality.

--Naval Air Rework Facilities have made multibuys primarily to save money and improve commonality. However, multibuys may not continue to receive the emphasis they once did. In the past the Naval Aviation Logistics Center grouped similar machine requests regardless of differing local facility priority designations. Center officials stated that, in the future, local priority designations would be used. Therefore, similar machines with lower priorities may not be procured in a group buy.

--Arsenals do not have common computer support arrangements. For instance, the Rock Island Arsenal uses UNIAPT on a minicomputer and Watervliet uses a commercial time-share service. Further, the headquarters does not sponsor multibuys of equipment.

WORK INTERCHANGE

One of the justifications for producing work in-house, according to OMB Circular A-76, is the unavailability of

the product or service from a commercial source or from another Government activity. Also, a DOD directive states that each DOD component should request support from another component when it is available and when such support is to DOD's overall advantage. Components are to provide support to the extent that military requirements and capabilities permit, and interservice and interdepartmental agreements are to be made. In consonance with this policy and in particular regard to expensive NC equipment, interchanging work between activities could eliminate procurements of additional machines and increase the use of presently owned machines.

Our 1975 report pointed out the potential excess capacities in various activities in the San Francisco area. In this followup analysis, we visited two activities in the area to inquire about actions taken to improve work interchange. The Defense Logistics Agency had convened an Interservice Support Seminar of 14 agencies in the area to discuss support capabilities among the agencies. Apparently, neither the seminar nor our prior report had prompted any interchange of NC work. However, in one example interchange appeared desirable.

--The Sacramento Army Depot is faced with a requirement to produce about 27,000 hours in the next year of conventional punching work. To deal with this requirement, the depot has been operating its two conventional punches about three shifts, 5 days a week. To reduce the burden for the multishifts, the depot has requested two additional conventional punches and has acquired an excess NC punch which is not yet operational.

--The Sacramento Air Logistics Center, about 12 miles from the Sacramento Army Depot, told us it is concerned with low utilization on its NC punch and would like to receive additional work. The Center's punch is used less than one-half of the Center's goal, and the Center has operators, programing time, and programers to assume additional work.

According to our observations, the punching work being done by the Army depot is ideally suited for the Air Force's machine. To test what constraints might be involved in exchanging work, in May 1978 we suggested the Army depot contact the Sacramento Center about transferring NC punching work. Numerous meetings were held between the depot and the Center, and in July 1978 we were advised that the Air Force had agreed to do 10 work orders for the Army, which totaled about 900 hours (including 64 hours of NC programing

time that the Air Force agreed to provide free). However, the 900 hours included only 79.5 hours of NC machine work, and the Air Force advised additional work orders could not be accepted due to a lack of capacity in functions other than NC operations.

We asked why whole work orders had been transferred rather than NC operations. Apparently, this inquiry prompted additional negotiations between the Army and Air Force. We were later advised that (1) the Air Force had proposed to do additional work, (2) some of the work orders involving punching could not be transferred due to intermittent other work operations required for the parts, and (3) the Army depot planned to contract for punching.

Although final arrangements have not been made at these two facilities, in our opinion, the ability of the Air Force to assume work of the Army depot could reduce or negate the need for some of the Army's additional equipment procurements and increase utilization on the Air Force's machine.

At the other installations visited, there apparently was little work interchange. Although the Norfolk Naval Air Rework Facility stated it had done several jobs for other facilities, the Norfolk Naval Shipyard had performed only one job for another shipyard, the Rock Island Arsenal had done one job for another agency, and Warner Robins had done no work for other activities.

Clearly there is little incentive at local levels to pass workloads on to other activities unless prompted from higher levels.

WORKMIX STUDIES

Determining what work should be done and properly doing workmix studies is necessary to determine the types, sizes, and number of machines most suitable for an activity. Such studies should include statistical analyses of parts, including lot size; estimates of machining time; number of sides and size of parts; type of machining operations; etc.

According to our earlier reports, activities did not have effective procedures for analyzing workloads. They usually bought NC equipment only when conventional equipment deteriorated or when new workloads were anticipated.

In an April 1975 memorandum the Deputy Secretary of Defense discussed DOD's cost reduction initiative and stated there were numerous opportunities to obtain significant cost

savings in production of Defense materiel by increasing the application of state-of-the-art manufacturing techniques and by developing new and improved manufacturing technology. The memorandum further stated that DOD should be using NC machines more effectively. Yet not all DOD activities are emphasizing more productive techniques.

The earlier reports noted that large amounts of conventional equipment were being procured and suggested that stronger consideration be given to NC equipment. Also we pointed out alternatives to new NC equipment buys, such as having another activity do its NC work or continuing operations at less than full productivity when NC equipment investments would not be economical. Our latest work shows that a large portion of conventional equipment is still being purchased, as shown in the following table, which includes procurements by DOD 1/ from 1973 through 1977 by categories of machines. The conventional machinery shown includes only that which would be considered to have NC counterparts.

Item	NC		Conventional		Percent NC/Total (dollars)
	Units	Dollars	Units	Dollars	
	(000 omitted)		(000 omitted)		
Machining centers	39	$11,936	12	$1,829	a/86.7
Boring mills (horizontal)	5	1,226	7	939	56.6
Boring mills (vertical)	19	2,518	12	1,747	59.0
Drills	6	492	66	1,427	25.6
Lathes	71	10,078	449	16,423	38.0
Mills	28	2,820	315	7,939	26.2

a/The high percentage of machining centers would be expected since they are mostly indigenous to NC.

1/Excludes Air Force Logistics Centers' procurement data which was not readily available.

Most activities are still not doing overall workmix studies. Procedures used by activities to determine equipment needs as described by activity personnel follow.

--In 1977 the Warner Robins Air Logistics Center analyzed 6 months' work from historical parts analysis sheets which describe machining operations required, number of sides and size of parts, setup time, fixture costs, and machining time. Information from this analysis was modified by other considerations, such as whether larger tables would be economical to allow multiple setups and whether another axis would eliminate a setup. Using this methodology Warner Robins identified five additional NC machines to be the equipment most suited to the work and initiated procurements and actions to excess some existing machines. Beyond this, two other machines were identified as necessary for predicted future capability. Since 1975 Warner Robins has bought no conventional equipment which has NC equivalents.

  Since the Warner Robins study, the Air Force has issued its directive on managing NC equipment, which requires all centers to perform workmix studies using a uniform methodology.

--The Norfolk shipyard's procedures for identifying needed equipment are the same as when we did our earlier work--machine requests originate in the shop primarily when machines deteriorate, and only the portion of the work necessary to justify the machine requested is analyzed. During our earlier study, we observed that the type and mix of the nine NC machines at the shipyard did not appear suited to the work. The machines were too large, of a restrictive point-to-point variety, or were too sophisticated. The NC equipment at the shipyard has not changed since our earlier study, and we were told the composition and type of work has remained the same. Although the shipyard has not bought any NC machines, since 1975 it has bought and installed over $600,000 of conventional equipment with NC equivalents. Shipyard and Naval Sea Systems Command personnel told us that the shipyard must improve utilization of existing NC equipment before more appropriate equipment can be bought. However, during our current review, the shipyard requested a consultant to study the work being done, NC machines needed, and management of NC operations.

--Norfolk Naval Air Rework Facility shop personnel identify needed machines by looking for production bottlenecks and deteriorated equipment. In addition, they discuss equipment needs at annual joint facility meetings and decide on common needs. Only the portion of work necessary to justify the equipment requested is analyzed. As in the past, when conventional machines are requested, the activity must explain why NC equipment is not appropriate. Since fiscal year 1976, the facility has bought six NC machines costing $1.8 million and only one small conventional machine which would have an NC equivalent.

--The Sacramento Army Depot, identified in our 1975 report as having most of its work more suitable for NC equipment, has not made workmix studies. Rather, equipment requests are prompted from shop personnel based on production bottlenecks, deterioration of present machines, or other inability to meet the volume of work. Local officials recognize a need for NC equipment--particularly for punching--and a consultant's study of the depot recommended NC equipment. The depot has had difficulty in obtaining NC machines because their high cost requires extensive justification.

UTILIZATION REPORTING

Management must have accurate and timely data on equipment use to exercise effective control. As in our earlier reports, the activities had different systems for recording use and recorded different factors, as shown below. All these activities use manual input instead of meters or other automatic recording systems to compute time. At Rock Island machinist time spent is considered machine run time, whereas the other activities record machine status. Also some data recording systems are questionable.

--At Rock Island the initial machine used on a job, we were told, may be charged with all hours whereas several machines were actually used, and sometimes a wrong machine is charged. Such errors, we were told, are obvious when a machine is removed from the shop yet is still reported as being used. Further, data concerning the 47 NC machines are scattered throughout a computer printout, which includes 2,500 conventional machines.

--Utilization reports are not prepared for all NC machines. For example, two machines at the Norfolk

Naval Air Rework Facility and two machines at Warner Robins Air Logistics Center are omitted.

--The Naval Sea Systems Command uses an overall system which is not realistic because it does not indicate how much the machine is being used or what for. The command system averages spindle and power meter readings to indicate machine use. Because of the inadequacies in such a system, shipyards have developed separate manual recording systems with more categories. Command officials advised that they recognized the inadequacies of the current system and had already investigated a commercial real-time recording system but had rejected it due to its high cost and the small number of NC machines at each shipyard. Officials further stated they would continue to search for better, cost-effective systems.

In addition to the differences between the Naval Sea Systems Command and shipyards' systems, other commands require different reporting procedures than are used at the activities. The Air Force Logistics Command requires monthly utilization reports of runtime only, the Army Armament Materiel Readiness Command gets reports from arsenals on an unscheduled basis, and the Naval Aviation Logistics Center requests a summary of local reports.

Improved management visibility through more indepth reporting could help to increase machine use and efficiency. For instance, if information were available to show time spent loading and unloading parts, management might find that multiple tables, which allow raw material to be loaded while a part is being machined, would be a wise investment. The number of delays due to errors in tapes could alert management to the need to improve tape verification methods. Long turnaround times for tapes could indicate a need to increase computer facilities or upgrade programer efficiency. More uniformity in both procedures and categories of recording data could assist at higher levels in such matters as interchanging work or detecting needs to add or delete equipment.

FOLLOWUP ANALYSES

Knowing the results of NC equipment in use can help to determine future needs and actions needed to increase productivity. The activities did not always have followup systems adequate for determining such needs and actions. Most activities made some attempts to follow up on the benefits

of NC equipment, but the data did not seem adequate for management to decide whether investments were sound or to pinpoint problem areas. Also emphasis on the need for such data seemed to vary among the activities.

DOD Directive 4275.5 requires a followup report. Headquarters groups have implemented different systems, and the Naval Aviation Logistics Center has waived requirements for a system. Most followup systems attempt to detemine whether predicted savings have been achieved; however, the frequency and methodology for savings computation vary considerably. For example:

--The Warner Robins Air Logistics Center reports monthly savings to the Air Force Logistics Command calculated from analysis sheets for all jobs done on the machine during that month. The sheets show cost estimates to produce the part on NC versus conventional equipment. The difference is the estimated savings or loss.

--Shipyards report savings to the Naval Sea Systems Command annually. During the first 2 years of a machine's operation, at least six work samples are analyzed to determine the productivity increase ratio of making parts on NC versus conventional machines. The ratio is applied to the hours the machine is used each year and converted to savings using the hourly shop rate. Machine utilization is calculated by averaging the power meter time and spindle meter time.

--For Army arsenals one followup is done on each machine about 1 year after it is placed in operation. Instructions require verification of all categories of savings predicted in the justification process.

Each of the systems has deficiencies.

--The Warner Robins Air Logistics Center does not properly include programing costs in its analysis of conventional versus NC machining. The Air Force cost accounting system requires these costs to be charged to overhead.

--Since the shipyards' averaging of power and spindle meter readings does not realistically reflect machine utilization, followup analyses are similarly affected.

--At the Rock Island Arsenal, no attempt is made to validate the predicted productivity increase ratios used in justification documents.

In general none of the followup systems assess all benefits predicted in justification documents. Items usually mentioned in justifications but not verified include productivity increase ratios and whether savings occurred from excessing equipment, reducing scrap, reducing personnel, saving power, reducing tools and fixtures, and reducing maintenance costs.

SELECTING WORK FOR NC EQUIPMENT

The lack of good systems for selecting numerical control work may result in many numerical control jobs being missed and, therefore, overall production may not be as economical as possible. Most activities continue to use informal systems for selecting NC parts. Documented analyses of parts could assist in selecting the more economical method and can be used to identify a need for particular machining capabilities.

The best system we observed was one used by the Air Force. It documents and quantifies cost comparisons of different machining methods and includes lot size, setup, fixturing, and machining hours. Additional factors are used to select the right machine, including percent of different type operations and number of sides to be machined. Within the Air Force cost accounting system, programing cost is not charged to the specific job, therefore biasing the selection process in favor of NC. 1/ However, even with this bias, the system forces a documented analysis of each part regardless of machine workloads, and the documentation can identify the number and types of machines needed.

In contrast, other activities generally use informal procedures.

--At the Norfolk Naval Air Rework Facility, planners evaluate jobs and discuss the NC candidates with the programers. The analysis is not documented. Factors considered in selecting parts for NC

1/The Warner Robins Air Logistics Center has submitted a proposal to allow programing time to be charged only to NC jobs.

machines are complexity of parts, lot size, whether the job may be done again, and machining time.

--At the Rock Island Arsenal, process planners evaluate the jobs' applicability for NC machines without documenting the evaluation. Factors used to select the proper machining process are lot size, tolerance allowance, and part complexity.

--At the Norfolk Naval Shipyard, the Planning and Estimating Staff, who have recently received orientation on the activity's NC machine capabilities, stamp work orders as possible NC candidates. However, shop planners actually evaluate jobs for NC versus conventional machining. The evaluation process is not documented, but factors considered are complexity and quantity of items. A planner has recently been assigned to the NC section. Part of his job is to roam the shop and identify jobs being machined conventionally which should be on NC.

To illustrate how the lack of a quantified, documented system may cause potential NC jobs to be missed, at the Norfolk shipyard we were told the NC planner identified jobs daily which would be done better on NC. As an example, during our visit, he moved a job to NC equipment estimated to take 120 hours conventionally, but only 30 hours on NC.

REPAIR PART ACQUISITION

When NC machines are waiting for repair parts, the activities must resort to less productive conventional machines or delay production. Because NC machines are more productive, unscheduled downtime waiting for repair parts results in a quantum production loss. Our 1974 report cited examples of activities taking a month or more to process requisitions for repair parts. Since our prior reports most activities have reduced internal delays in procuring repair parts.

--At the Rock Island Army Arsenal, priority is assigned to requisitions for parts causing a work stoppage, thus reducing the time to get repair parts from 30 days to 1 week. Special procedures adopted include locating a vendor for the needed part before the requisition is processed, hand-carrying the requisition through supply, and picking up the part when received at supply instead of waiting for normal distribution.

--At the Warner Robins Air Logistics Center, all NC machine repair parts are assigned a higher priority than conventional machine repair parts so that processing requests usually takes only 5 days. This time can be reduced to 1 day when a work stoppage is involved by hand-carrying the request through supply.

--At the Norfolk Naval Shipyard, NC machine repair part requisitions are hand-carried through administrative processes, requiring about 1 day. When parts are received, supply notifies the shop so that the parts can be picked up immediately. The shipyard has also obtained repair parts from other activities when the vendor required a long leadtime. Within the last year the shipyard has obtained two parts from the Long Beach Shipyard and one from the Charleston Shipyard, in these cases receiving the parts in less than 1 week.

--At the Norfolk Naval Air Rework Facility, the repair part requisitions are hand-carried to supply when work stoppages occur. Sometimes internal procedures do cause delays. For example, a $35 part for a $200,000 machine was held up 1 week in the supply system after it was received. It is against supply policy to allow shop personnel to routinely pick up parts when they arrive. When long delays in getting parts from vendors are anticipated, Norfolk contacts other rework facilities. It has obtained about 20 repair parts in this manner in the last year, usually requiring only 2 or 3 days.

--According to Sacramento Air Logistics Center officials, the Center continues to have internal problems in getting parts. Unless a vendor for a needed part is located in the immediate vicinity processing a requisition averages about 30 days. However, the recently issued Air Force regulation on NC equipment management requires expedited procedures on a walk-through basis.

At the private companies visited, maintenance people telephone requests to vendors and request shipment. At one company the maintenance foreman has no dollar limit. Another company has established open purchase orders with vendors for several hundred thousand dollars against which telephone orders can be placed. With this arrangement, we were told, getting an order for a repair part to the supplier takes about 20 minutes.

We appreciate the constraints in which Government facilities operate in procurements of all items--as compared with private plants--however, it seems that uniform streamlined procedures could be developed for procuring repair parts for expensive NC equipment.

OTHER PROBLEMS

Activities noted and we observed problems in addition to the subjects we selected to discuss. These problems, which we did not fully explore, seem to be roadblocks for the activities and subjects for study or resolution to improve their numerical control operations.

--Several activities' personnel stated they had difficulty getting funds to attend NC conferences and seminars. In contrast, a private company noted that management encouraged its people to go to professional organization meetings and each department had adequate training and travel budgets.

--Several activities complained of disparity between pay for shop personnel and parts programers resulting in difficulty acquiring and retaining programers. However, private companies indicated that this was no problem and that a fair and reasonable salary would hold good programers. One company said its programers started out at midlevel of a top machinist's pay and that programers generally made more than machine operators.

--Wide variances exist in the ratio of NC machinists to NC machines, as indicated in the table below. The table shows that on the first shift the ratio of machinists to machines varies from 6:1 to 1.8:1. We were told that Rock Island has only

Activity	Number of NC machines	Number of machinists			
		Shift 1	Shift 2	Shift 3	Total
Rock Island Arsenal	47	28	13	13	54
Norfolk Naval Air Rework Facility	21	17	2	-	19
Norfolk Naval Shipyard	9	8	2	-	10
Warner Robins Air Logistics Center	8	14	10	4	28

28 machinists on the first shift primarily because of workload. Some machines are used intermittently, whereas others, such as machining centers and lathes, are used on multiple shifts. Warner Robins officials told us they needed more operators than machines because about 30 percent of their operators assigned were unavailable for duty due to leave, training, or other duties. Additionally, they said operators were needed on the first shift to set up work for machinists on later shifts and to do some finishing work on conventional machines.

In addition, one attendee at the Defense Industrial Plant Equipment Center NC Workshop suggested a subject to cover in future workshops should be the most efficient ratio of machines, foremen, part programers, tool setters, and machine operators.

--Productivity of programers varies considerably depending on computer support and other auxiliary equipment available, such as plotters and graphic terminals. Some activities have or plan to use such aids whereas others do not. The Naval Air Systems Command is procuring computer graphics for all its facilities; Warner Robins plans to add graphics instead of hiring programers; whereas neither Rock Island Arsenal nor Norfolk Shipyard 1/ plan to get such equipment. Also, among these four facilities, the Norfolk Shipyard is the only one without a plotter for verifying programs.

--Additional guidance may be needed to help activities determine when retrofitting is technically practical and economically feasible, particularly with the advent of computer numerical control offering the capability for machine diagnostics, program editing, and subroutine functions. Retrofitting may be more economical than new procurements. For instance, Warner Robins has estimated a half million dollar savings through retrofitting a large skin-milling machine. Other activities may be procuring new systems without considering the economic advantage of retrofitting.

1/Norfolk Shipyard officials stated they had requested graphics for other functions but had been unsuccessful.

In addition, a recent interpretation of Defense Logistics Agency regulations now allows the Defense Industrial Plant Equipment Center to fund retrofits. This may make more excessed equipment useful to activities.

--Procurement systems for NC equipment and data processing equipment for programing are cumbersome and lengthy. For example, the Aviation Logistics Center has been trying to buy computer graphics capability for Air Rework Facilities for over 3 years. Because this equipment is considered data processing equipment rather than production equipment, lengthy procedures are required to buy it. Also, according to Sacramento Army Depot officials, getting NC equipment after a need is identified may take 4 years.

While we recognize a reasonable time is required for procuring expensive equipment in both the Government and private sectors, we believe the lengthy delays due to Government procedures might be lessened. 1/

--DOD Directive 4151.1 requires that, to insure a ready source of resources to meet military contingencies, facility loading capacity will be on a 40-hour week, one-shift basis. Activities violate the directive because it prevents economic returns on NC equipment. For instance, the current Air Force Logistics Centers' goal is to operate NC equipment at 140 percent of 1 shift. 2/ In contrast, when Naval Air Rework

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1/In comparison with the Government activities, one large private company told us it took about 7 to 13 months from the time a need for a machine was identified until a contract was awarded.

2/The recently issued Air Force Logistics Command Regulation 66-50 states that the goal is 200 percent of 1 shift--using the third shift and overtime if necessary to achieve the goal. However, command officials have established lower, interim goals until 200 percent is considered.

Facilities use machinery 150 percent based on 1 shift, additional equipment is to be considered. Obviously, as discussed in our earlier reports, the activities continue to need clarification of the reserve capacity required.

--Organizational structures and management emphasis on numerical control vary among activities. For example, the Alameda Naval Air Rework Facility NC Committee reports to the production officer; the Norfolk shipyard coordinator reports to the shop superintendent, giving less visibility to NC than in other arrangements; the Warner Robins maintenance division manager has personal interest and involvement in NC operations; the Rock Island Arsenal, which had an NC coordinator at the time of our earlier reports, has abolished the position because the arsenal considers numerical control to be well established and accepted, thus requiring no special attention.

--Our earlier reports noted that data package exchange between industry and Government could reduce programing time and costs at Government activities for parts initially made by contractors on NC machines. Our discussions with both command and activity level personnel indicate that exchange would be beneficial, but mechanisms and policies still are needed to achieve such exchange.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

DOD has not adequately defined the industrial base capacity it needs but, nevertheless, is continuing to buy equipment. We pointed out in earlier studies--and in some cases DOD and the services agreed--that, to determine needed capacity, they must correct deficiencies in defining critical elements, such as scenarios and requirements, commercial surge ability, and allied resources. Without knowing the capacity needed, firm decisions cannot be made on (1) how much, if any, equipment is needed for replacement, modernization, or meeting mission requirements or on (2) what type of equipment would most efficiently accomplish the work.

Once such decisions have been made, numerical control offers benefits in terms of surge abilities, economy, and efficiency. NC can be productive or detrimental in achieving these goals depending on how it is managed.

Because of a lack of overall direction or coordination, there have been varying and inadequate degrees of attention among the service activities to NC as a productive mode of manufacturing. We had agreed with the proposed actions of DOD in response to our prior reports; however, these actions obviously have not been accomplished through the Tri-Service NC Management Committee, the Defense Industrial Plant Equipment Center, or the Manufacturing Technology Advisory Group. Some coordination has occurred through the annual workshops sponsored by the Center; some information exchange has occurred by the advisory group; and improvements have been made by individual commands, on their own initiative.

As pointed out in our prior reports, the individual activities and commands have few mechanisms to draw on the experiences of others or to work together in solving common problems. Coordination could preclude the need for individual components to develop independent procedures and policies to deal with the important factors relating to the management and use of NC equipment.

Further, the need for such a mechanism is illustrated by the conditions noted at activities/commands visited. These conditions include

--problems with and different approaches taken to deal with standardization;

--variances in, and a lack of, workmix studies to determine equipment needs;

--variances in the content, adequacy, and use of utilization reporting and followup systems;

--different approaches and inadequate systems for deciding which parts should be made on existing conventional or NC equipment;

--opportunities for further streamlining procedures to process orders rapidly for machine repair parts;

--no substantial actions to coordinate and set up systems to exchange work between activities to (1) improve utilization or (2) avoid unnecessary equipment procurements; and,

--various other technical and management problems among the activities visited, as noted on pages through

Because DOD is a major owner of NC equipment and is probably the largest single purchaser of products manufactured by private NC equipment, DOD would be a prime benefactor in developing cooperative standards and practices and in devising solutions to problems in numerical control.

While we agree that the draft DOD directive is aimed at many of the problems associated with NC's management and use, we view the directive as merely a first step; more needs to be done on a continuing basis. In our opinion, the directive alone is inadequate for dealing with the larger issues of (1) uniformity and exchange of data between services, (2) DOD/industry/Government cooperation, (3) establishment of a resource activity for the services, and (4) enforcement of sound management practices among the services.

RECOMMENDATIONS TO THE SECRETARY OF DEFENSE

Since proper implementation of NC equipment could significantly improve the productivity of DOD's industrial base and provide greater surge capability, we recommend that the Secretary

--activate a DOD or combined-service group or assign to an existing group the responsibility to provide overall technical and policy direction and coordination for NC equipment. The group should periodically provide progress reports.

The Secretary should require the group to address the areas suggested in our 1974 report, which were to:

--Develop and enforce a policy encouraging interservice standardization for both NC hardware and software.

--Improve the systems for identifying opportunities for NC. Adequate workmix studies should be made, and NC equipment should be considered when conventional equipment is requested.

--Improve the planning for NC machine purchases by developing guidelines on planning for NC as a total production system.

--Investigate the establishment of a Government-wide inventory of NC repair parts and require activities to consider that inventory before buying complete spare parts kits.

--Clarify the policies on multishift use and reserve capacity of NC equipment to obtain maximum use of such equipment.

--Improve the management of NC. The activities need (1) better management information on machine utilization, (2) more training for NC, (3) criteria and procedures, including cost comparisons, for determining what work should be done on NC equipment, (4) adequate preventive maintenance programs, (5) authority to give priority to procuring needed repair parts, and (6) better systems for exchanging work between similar activities and between services.

--Study the possibilities of reducing inventories through NC and of exchanging NC data packages.

--Establish uniform guidelines on developing followup systems which will more accurately disclose the true savings and costs of NC equipment.

Further, as covered in our 1975 report, we again recommend that the Secretary of Defense:

--Require that no justifications for new machines be approved unless the activity has adequately considered using the capacities of other activities in the geographical area.

--Insure that the necessary computer support and programers are available to meet mobilization requirements.

AGENCY COMMENTS AND OUR EVALUATION

We discussed this report with officials of DOD and the services. They stated there would be definite advantages to more coordination of NC activities among the services and installations. DOD and services agreed there was a role for some type of interservice group or function to share ideas, reduce duplication, and work on mutual problems. However, the consensus of the services and other DOD components was that such a group not be directive in nature but that it should be constructed so that policies should result. Concern was expressed as to:

1. Why one segment of plant equipment, such as numerical control, should be singled out for special management.

2. How the group would be organized and who would participate in it. Consideration has been given to several alternatives, such as including it under functions of the Joint Logistics Commanders, the Defense Industrial Plant Equipment Center, or the Manufacturing Technology Advisory Group.

3. The availability of funding for such a group.

4. Whether DOD should bear the burden of establishing working relationships with the Department of Energy and the National Aeronautics and Space Administration.

5. Whether the subjects described for study in DOD's responses to our earlier reports were still appropriate.

Even with these concerns and despite some views that there was no need for such a group, the officials stated that positive actions would be taken and that, for now,

the Defense Industrial Resources Support Office would be responsible for recommending future actions and for coordinating the draft directive on management of NC equipment.

We agree that more coordination is needed. However, in that DOD cannot define what particular actions it will take on this report, we cannot decide on the appropriateness of plans and actions. We disagree with some views expressed, such as whether numerical control warrants special attention. We believe it does in view of its relative potential to contribute to overall productivity. We also point to the large amounts of conventional equipment procurements which might well have been NC procurements and the problems some services and activities are having. Therefore, we plan future inquiries into the matters discussed in this report and DOD's actions to address these matters.

CHAPTER 6

SCOPE OF REVIEW

The objective of this review was to follow up on the actions of the DOD and services regarding matters covered in our 1974 and 1975 reports to the Congress on improvements needed in managing and using numerical control to increase productivity in the Defense establishment. After learning early in the review that little had been done in relation to the earlier reports, we selected several subjects covered in the early reports and tested whether improvements had been made at several Government-owned, Government-operated facilities. We knew, in performing the review, that conditions regarding Government-owned NC equipment in contractor operated or owned facilities were likely to be the same as in our earlier studies because DOD had done little to improve the Defense use or entire field management of NC.

At the Office of the Secretary of Defense and at the following service headquarters, our work involved discussing policies and procedures and analyzing reports, instructions, and other documents on managing and using NC equipment.

--Naval Sea Systems Command, Alexandria, Virginia.

--Naval Aviation Logistics Center, Patuxent River, Maryland.

--Army Materiel Development and Readiness Command, Alexandria, Virginia.

--Army Depot Systems Command, Chambersburg, Pennsylvania.

--Army Armament Materiel Readiness Command, Rock Island, Illinois.

--Air Force Logistics Center, Dayton, Ohio.

At the following activities we toured shops; discussed policies and procedures; and briefly analyzed reports, instructions, and other documents on managing and using NC equipment.

--Norfolk Naval Shipyard, Portsmouth, Virginia.

--Naval Air Rework Facility, Norfolk, Virginia.

--Rock Island Arsenal, Rock Island, Illinois.

--Warner Robins Air Logistics Center, Warner Robins, Georgia.

We had discussions and tours at two private plants, one large manufacturer of aircraft, and one company which produces thousands of different items in low volume and in response to customer orders for a short turnaround time.

At the Sacramento Army Depot and the Sacramento Air Logistics Center, we briefly discussed NC operations and, in particular, addressed opportunities for work interchange between these activities. In addition, the Defense Industrial Plant Equipment Center, Memphis, Tennessee, provided statistics and views on its current and possible future roles concerning NC equipment. Officials of the National Aeronautics and Space Administration and the Department of Energy provided data on their inventory of NC equipment.

Mr. James J. Childs, a leading numerical control consultant and author of numerous numerical control articles and textbooks, assisted us in a technical advisory capacity.

APPENDIX I

COMPTROLLER GENERAL'S REPORT TO THE CONGRESS

NUMERICALLY CONTROLLED INDUSTRIAL EQUIPMENT: PROGRESS AND PROBLEMS
Department of Defense
B-140389

D I G E S T

WHY THE SURVEY WAS MADE

Numerically controlled (NC) industrial equipment includes drills, mills, lathes, etc., controlled automatically by punched tape. NC equipment is expensive and complex but offers tremendous productivity increases and savings in industrial operations--particularly for small-lot production. In 1973 the Department of Defense (DOD) owned $300 million worth of NC industrial equipment.

GAO surveyed how industrial activities identify where numerical control can increase productivity, plan for NC-machine purchases, manage numerical control, and follow up on its benefits. This survey, made in each military service and at two contractor plants, provides information on observed progress and problems.

GAO has a more detailed review underway covering the management of NC equipment.

FINDINGS AND CONCLUSIONS

DOD's role in advancing numerical control

Advancement of numerical control may be limited because users are confronted with many different NC systems and different standards. DOD could do more to develop the field and bring about more standardization. A more concerted, active DOD role in researching and developing the numerical control field and in working more closely with industry could directly benefit DOD, since it is a major numerical control user. (See p. 11.)

Systems for identifying a need for numerical control

Activities surveyed had no formal systems for identifying where numerical control could be economically used. They did not have adequate staffs to search out opportunities, did not make work mix studies, and usually bought NC equipment only when conventional equipment deteriorated or when new workloads were anticipated. Large amounts of equipment were planned for procurement, but very little was NC. (See p. 16.)

Planning for specific NC equipment

Once a need for numerical control has been identified, both short- and long-range plans should be made to get the most productivity. Plans should view numerical control as a total package, including computer support, organizational responsibilities, personnel, spare parts, and prompt installation. These matters may need increased attention. Also, justification documents do not seem adequate for sound planning. (See p. 21.)

Management of NC equipment in use

If NC equipment is properly managed,

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use rates generally will be high. Use appeared lower than it could be, but it could increase if:

--Management had adequate data on equipment use.

--Activities had formal guidelines for determining which jobs should be done on NC equipment.

--Policies restricting multishift use were eliminated or clarified.

--Preventive maintenance programs were improved.

--Repair parts were acquired more quickly.

--Work interchange programs were improved.

Some indirect benefits of numerical control have not been taken advantage of.

--None of the activities had programs to reduce logistics support costs by stocking tapes instead of spare parts.

--Tape package exchange programs were not working.

--Higher skilled operators than may be needed are used. (See p. 28.)

Followup systems to assess benefits

Although all activities are required to have followup systems that show the actual savings from NC equipment, not all had such systems. Some systems in use produced questionable information. (See p. 43.)

RECOMMENDATIONS OR SUGGESTIONS

The Secretary of Defense should establish a DOD group to coordinate the services' use of numerical control and to work with industry in further developing the numerical control field. Such a group should:

--Develop and enforce a policy encouraging interservice standardization for NC hardware and software.

--Improve the systems for identifying opportunities for numerical control. Work mix studies should be made, and NC equipment should be considered when large amounts of conventional equipment are requested.

--Improve the planning for NC-machine purchases by developing guidelines on planning for numerical control as a total production system. Also, more input from higher levels is needed to insure more accurate justification documents.

--Study the possibilities of reducing inventories through numerical control and of exchanging NC data packages.

--Improve the management and use of numerical control by implementing the management improvements suggested on page 48.

--Establish uniform guidelines on developing systems which will more accurately disclose the true savings and costs of NC equipment.

The Secretary of Defense also should (1) work with the General Services Administration, the Atomic Energy Commission, and other Federal agencies having responsibilities for and interest in the

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future of numerical control and (2) consider to what extent DOD should sponsor research and development in the numerical control field. (See p. 47.)

AGENCY ACTIONS AND UNRESOLVED ISSUES

DOD plans to establish a triservice organization to improve the management and use of NC equipment, devote attention to equipment and software standardization; analyze the contribution of computers, controllers, and computer-aided manufacturing; and examine NC-equipment maintenance and personnel training. This offers potential to improve many areas noted in the survey.

DOD also plans to study whether spare-parts stockage for weapons can be economically reduced by numerical control.

Concerning its continuing work to develop the numerical control field, DOD pointed out it had pioneered numerical control to demonstrate its benefits to industry, and it believes that, if largely financed and monitored by industry, a more lasting program will develop.

DOD acknowledged that numerical control's effective application was a broad national matter requiring contributions from industry, universities, and Government agencies.

DOD also stated tnat such a program would require national leadership, possibly by the President's Commission on Productivity or by the Office of Technology Assessment. DOD also pointed out it was participating with a variety of organizations on how best to increase productivity through automated manufacturing.

MATTERS FOR CONSIDERATION BY THE CONGRESS

NC equipment can enhance productivity and can help improve the Nation's technology. This report, by informing the Congress of the progress and problems in moving toward more modern production techniques, should assist it in evaluating defense plant modernization programs and requests for additional plants and capabilities.

In addition, the Congress may wish to consider whether DOD should expand its research and development to take full advantage of the benefits of numerical control and whether more efforts are needed to promote industry and Government interests in working toward more standardization in the numerical control field.

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COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

USE OF NUMERICALLY CONTROLLED EQUIPMENT CAN INCREASE PRODUCTIVITY IN DEFENSE PLANTS
Department of Defense

D I G E S T

WHY THE REVIEW WAS MADE

A previous GAO survey showed how Department of Defense (DOD) industrial activities plan for and manage numerically controlled industrial equipment--a relatively new technology.

The report 1/ recommended that the DOD Secretary establish a group to coordinate and improve the military services' use of the equipment--controlled by punched tape or computers--and to work with industry in further developing the field of numerical control. DOD subsequently did so.

GAO made this review to assess the full extent of problems previously noted and to find methods for improvements.

FINDINGS AND CONCLUSIONS

Numerically controlled industrial equipment is expensive and complex. It includes drills, mills, lathes, machining centers, and other machines controlled automatically by punched tape or computers.

If properly managed, this equipment offers tremendous increases in productivity and savings in industrial operations--particularly for small-lot production. (See p. 2.)

Need to better define work of Government activities

The Government relies on private enterprise for goods and services except in certain situations, such as when production in its own plants is necessary to meet readiness requirements.

Original manufacturers and private machine shops could handle some of the numerical control work being done at DOD plants--at less cost in some cases.

Also, some DOD activities had unused numerically controlled machine capacities which others could use. DOD recognizes this situation but believes that some unused capacity must be maintained for emergencies. (See p. 6.)

Need to make work-mix studies

Once the type and amount of

1/ "Numerically Controlled Industrial Equipment: Progress and Problems" (B-140389, Sept. 24, 1974).

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work to be done in DOD plants is decided, studies should be made to identify the more efficient production method for the work--conventional or numerically controlled machines.

Most DOD activities did not have effective procedures for making such studies. The activities' machines did not always suit their work. GAO's sample studies showed that some activities

--could effectively use more numerically controlled equipment;

--had overly elaborate, expensive equipment not required for the work; or

--had, or were ordering, numerically controlled equipment for which little work existed. (See p. 21.)

GAO prepared a step-by-step procedure which should assist activities in justifying procurements and in selecting the appropriate type and number of machines. (See app. I.)

If activities find that their machines and workloads are unsuited, procurement of additional machines is not necessarily the wisest solution. Management should first compare the costs and savings of all alternatives, including

--declaring equipment surplus and transferring it to others,

--continuing operations at less than full productivity, and

--having another activity do its numerical control work. (See p. 26.)

Information on Government-owned numerically controlled machines

GAO sent questionnaires to the 225 activities which had Government-owned numerically controlled equipment, asking for data on the management and use of the equipment. The data showed that:

--Many activities planned substantial future investments in numerically controlled equipment.

--Many different types of computer arrangements were used with varying amounts of turnaround time.

--Government activities did not develop postprocessors in-house to the extent that contractors did.

--A variety of different languages were in use, although languages seemed to be approaching standardization.

--Machine-use reporting systems were extremely diverse. Contractors seemed to use their numerically controlled machines more than did Government activities.

--Most activities did not consider manufacturers' recommended spare-parts kits appropriate. Those activities which bought kits spent more than those which developed kits through experience.

--Many activities had problems

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getting repair parts quickly, partly due to cumbersome procurement systems.

--Activities generally used qualitative factors in selecting jobs for numerically controlled machines. Cost models or comparisons would be more helpful.

--Data package interchange could save programing time, but first, numerically controlled systems must become more standardized and records of parts programed must be more visible.

--Followup systems were not always used to assess whether numerical control was as productive as possible and to notify management of problems. (See p. 29.)

Costs of numerically controlled systems

The direct and support costs of numerically controlled systems are considerable but vary widely, depending on the machine system and type of work.

Realizing savings from numerical control requires that the critical factors involved be closely studied and managed. A cost model prepared by GAO to illustrate this important matter can be found on page 51.

The prime factor in keeping numerical control cost effective seems to be high use. To achieve a payoff over conventional production, numerically controlled machines should usually be used at least one full shift. (See p. 45.)

Obtaining the benefits of numerical control

Although numerical control offers many benefits in terms of cost savings, high tolerances, and ability to meet mobilization requirements, it is no panacea. To fully benefit, activities must closely plan for numerically controlled machines as a total production system. Thus far the cost savings achieved and the ability to meet mobilization requirements have been less than planned. (See p. 54.)

RECOMMENDATIONS

The Secretary of Defense should:

--Require that no justifications for new machines be approved unless the activity has adequately considered using the capacities of other activities in the geographical area.

--Insure that the necessary computer support and programers are available to meet mobilization requirements.

In addition, the triservice numerical control committee should insure that work-mix studies are made to achieve a better match of machines and work and to identify opportunities for cost-effective investments.

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AGENCY ACTIONS AND UNRESOLVED ISSUES

DOD said it believed that the current guidance on capacities which activities need in emergencies is adequate and comprehensive. DOD also said that an activity's total production requirements and rates are used to determine the production equipment, and thus the capacity, needed in a mobilization, keeping in mind the items' make-or-buy situation.

GAO believes DOD's guidance is not definite because, as GAO's earlier report pointed out, both commands and installations interpret the guidance differently.

Also, DOD has no reasonable basis for determining an activity's total requirements because many activities do not know what items they will have to produce.

DOD also said that its existing procedures for soliciting bids from private machine shops are adequate and that the decision to make or buy an individual item cannot be viewed as an isolated case.

Although GAO agrees that a decision to make or buy an item should not be viewed as an isolated case, the decision should include more emphasis on the comparative costs of Government and commercial production since many commercial shops can provide items in the time required. With this increased emphasis, DOD could more economically use those capacities which are determined to be required for a mobilization but which are excess to peacetime needs.

In commenting on GAO's recommendation to use other activities' unused capacities before requesting in-house machining capability, DOD said it had made every attempt to achieve that goal. DOD recognizes, as does GAO, that work exchange may be inhibited by reprograming effort, the limited exchanges of numerical control data packages, and the lack of standardization in hardware and software.

DOD said its triservice numerical control committee, established as a result of GAO's previous report, had prepared a Draft DOD Instruction 4215.xx, "Management of Numerically Controlled Industrial Plant Equipment," as a major step toward improving the management of this equipment.

The draft instruction addresses:

--Planning (including personnel and computer support for peacetime and mobilization workloads and work-mix studies to improve the identification of the types of machines required).

--Economic justifications and followups.

--Utilization.

--Preventive maintenance and

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spare-parts acquisitions.

--Inventory reporting.

--Standardization of hardware and software.

This instruction, when implemented, should be of great help to activities in better planning for and managing their numerically controlled machines.

MATTERS FOR CONSIDERATION BY THE CONGRESS

GAO's report provides information on the nature of numerically controlled equipment, its high costs, and the special management needed to make the most of this relatively new technology. Ultimately, such information should provide a basis for judging the thoroughness of research done to support requests for additional facilities and equipment.

This information may also be useful to the Congress in considering Senate bills 765 and 937 because numerically controlled equipment, and its associated use of computers, is important to improved productivity both in the Government and in private industry.

SUMMARY OF PRIOR REPORTS CONCERNING DOD PLANT CAPACITY AND CAPABILITY

"Air Force Maintenance Depot -- The Need for More Responsiveness to Mobilization As Well As Peacetime Efficiency," LCD-78-403, Nov. 23, 1977

The Air Force maintains depot repair capability to assure a controlled source of competence to keep aircraft and other equipment ready in peacetime, sustain this hardware in the initial surge of a contingency or war, and provide a base for rapid expansion. Responsiveness, immediate and flexible, is considered to be of a higher priority than the need to obtain efficiency for peacetime operations.

Air Force planners have been concerned about the ability of depots to respond to high surges in maintenance during a war or contingency of intensity and short duration. Maintenance depots, as currently configured, cannot support requirements which the Air Force anticipates in a "surge" period for most of its weapon systems. Under these conditions, the Air Force had to determine which systems could and could not be supported. We questioned the Air Force plans because flying-hour estimates for high surge transport aircraft exceeded the number possible under present conditions.

Even if flying-hour estimates were not questioned, the Air Force needs to consider subsidiary factors distorting its estimate of readiness, such as not fully assessing the

--ability of contractors to meet their share of the surge requirements,

--number and skill levels of people needed to meet surge requirements at depots,

--ability to hire and train people needed in each geographical location,

--estimates for repair parts, and

--facilities and equipment bottlenecks in the depot production process.

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"Navy Aircraft Overhaul Depots Could Be More Productive," LCD-75-432, Dec. 23, 1975

Millions of dollars could be saved at the Navy's aircraft overhaul depots by improving its production control system and by revising its present concept of maintaining components. In addition, industrial capacity for both peacetime and wartime should be determined for better balance and use of manpower and modernization funds.

Under Department of Defense criteria, the Navy's six aeronautical depots operate on a one-shift, 40-hour week, or less than one-fourth of the total time available. The reserve depot capacity, under this concept, could be tapped by adding extra shifts. The Navy, however, has no program to quantify systematically the amount of depot-level capacity needed for mobilization.

We developed a model which projects an approximation of workload and manpower on the basis of the Navy's current mobilization flying-hour scenario. On the basis of this model, current depot-level capacity far exceeds mobilization needs. We proposed several alternatives which could reduce in-house capacity needs without compromising readiness by:

--Developing a system for calculating mobilization workload and manpower requirements.

--Operating fewer depots, up to two full 8-hour shifts a day, 5 days a week in peacetime.

--Relying more on contractors for maintenance support.

--Making greater use of other services' capabilities and capacities.

--Making better use of resources located below the depot level.

--Exploiting the full potential of maintenance capability and capacity according to technology rather than by weapon system.

We recommended that the Secretary of Defense consider a policy of operating maintenance depots more than one shift, 40 hours a week, and:

--Establish true mobilization needs and prepare contingency plans for staffing to such needs.

--Consolidate, eliminate, or place in reserve status, as appropriate, all excess depot capacity.

--Concentrate modernization funds in only those depots with long-term value and tailor each modernization project to definitive long-range plans.

"Management of Department of Defense Industrial Plant Equipment Can Be Improved," LCD-76-407, Oct. 5, 1976

The Department of Defense owns more industrial plant equipment than may be needed for peacetime and mobilization requirements. The amount needed by the services should be based on total peacetime and mobilization requirements, less that equipment available in private industry to fill Government orders. However, the services have understated the number of hours that individual machines will be run in a mobilization, and that is why, in part, more equipment than may be needed has been retained.

During peacetime most activities operate one 8-hour shift a day, 5 days a week. DOD has not given the services explicit policy on how to determine needs for industrial plant equipment during mobilization. As a result, the services have

--established different criteria for determining those needs,

--understated the number of available production hours, and

--overstated industrial plant equipment needs.

We recommended that the Secretary of Defense:

--Establish standardized criteria for planning industrial plant equipment needs and develop new standardized instructions so that the services could establish more valid plant equipment requirements to meet their mobilization production needs.

--Revise the procedures for justifying the replacement of industrial plant equipment to insure that the justifications are based on accurate data and that the replacements are economically sound or are adequately justified for mobilization surge needs.

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--Centralize the responsibility for industrial plant equipment management to provide a mobilization reserve with the resources available at Government facilities and in the private sector.

"Determining Requirements for Aircraft Maintenance Personnel Could Be Improved--Peacetime and Wartime," LCD-77-421, May 20, 1977

The military activities usually determine below-depot aircraft maintenance manpower required for wartime operations, and within the existing budget constraints, most activities attempt to staff for wartime operations. The services have done little to develop systems to determine what staffing is required for peacetime.

Each service approaches the manpower determination process using its independently developed systems assumptions, rules, and policies. We found problems within this process.

--In many cases manpower factors and data used in the individual manpower determination systems are questionable, inaccurate, or outdated. Refinement of the existing systems and information used to determine maintenance manpower requirements is necessary if the services are to determine the most appropriate level of maintenance manpower for both wartime and peacetime.

--Assumptions concerning the use of military forces underlie each service's manpower determination system and greatly affect the manpower requirements. Reevaluating these critical assumptions could lead to reductions in manpower requirements.

For example, the services' systems generally assume all deployable aircraft units must be ready to deploy immediately, but some units will not deploy during the early stages of war. We believed manpower requirements could be adjusted to reduce active duty manpower levels during peacetime and use reserves to augment some of these units during wartime.

"The Navy's Intermediate Ship Maintenance Program Can Be Improved," LCD-77-412, Sept. 23, 1977

The peacetime roles of mobile (tenders) and shore activities are identical--they perform regularly scheduled repairs on ships which are normally in their home ports. In wartime, however, the roles differ. War plans call for the deployment of most tenders to forward areas. This enables ships to obtain battle damage and other repairs near the scene of action.

According to the Navy, the wartime need for forward support dictates that at least part of the Navy's maintenance capability be mobile.

The current wartime and peacetime intermediate maintenance activity levels have developed without systematic consideration being given to many basic issues. Scientific engineering studies are needed to measure the Navy's intermediate maintenance workload under peacetime and wartime conditions. These studies would enable the Navy to estimate its total maintenance requirements more accurately and determine what portion of these requirements needs to be mobile. For example, the Navy has not analyzed how much maintenance would be required under the conditions of modern warfare--the number of ships that would be lost, the types of casualties that would occur, and how much of this work could be done by the tenders and repair ships.

Past studies which attempted to measure mobile repair facility requirements used repairs performed in peacetime as a basis for determining wartime requirements. No determinations were made concerning whether repairs actually made should have been made, what would happen if they were deferred, or whether they would be necessary in the forward areas of conflict. Once wartime requirements have been defined and the most appropriate level of effort established--the number of activities, their capabilities and capacities, and whether they should be mobile or ashore--then the peacetime maintenance can be made more effective and economical.

"Naval Shipyards--Better Definition of Mobilization Requirements and Improved Peacetime Operations Are Needed," LCD-77-450, Mar. 31, 1978

Naval shipyards are to provide quick response industrial work in peacetime to support fleet needs, and sufficient capacity and capability to meet workload surges in

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case of an emergency or a war. Since the primary justification for retaining depot maintenance capacity and capability in the Department of Defense is to meet emergency needs, it is therefore imperative that reasonably accurate predictions of emergency needs for shipyards be made to identify (1) the capacity and capability needed and (2) where they are needed.

Although the Navy has not routinely made such predictions, it assumes that wartime workloads are greater than those of peacetime. To determine the validity of this assumption, the Navy should

--quantify expected mobilization requirements,

--define expected work to be done at each level of maintenance and at private or naval shipyards,

--determine the amount of work which can be done at allied facilities, and

--determine how peacetime productivity levels affect shipyard capacity and capability needs.

These efforts are needed to be sure that shipyard modernization funds are optimally spent to support mobilization needs. The Navy has work underway to provide information on some of these issues. But it will be some time before all the issues can be fully evaluated.

We recommended that the Secretary of Defense, along with the Secretary of the Navy:

--Routinely determine shipyard mobilization needs and prepare emergency plans for staffing such needs.

--Insure that modernization funds are optimally spent to support mobilization needs.

DEFENSE ACTIVITIES, ACTIONS, AND PLANS REGARDING MANAGEMENT OF NC EQUIPMENT

--Defense Industrial Plant Equipment Center. The Center initiated annual workshops to bring together representatives of the service facilities that have NC equipment to provide technical assistance. The Center became aware that activities were having common problems in NC, and there was no communication between the activities for problem resolution. Another objective of the workshops was to discuss new developments in the Numerical Control/ComputerAided Manufacturing field. Additional participants included representatives of the National Machine Tool Builders Associations, the National Bureau of Standards, the Numerical Control Society, and industry equipment vendors and research laboratories. Response to the workshops was very favorable, and the Center plans to continue such sessions. Even with the success of the seminars, Center officials stated they believe there is a need for a "TriService" organization.

The Center is also expanding its data base on DOD-owned NC equipment to (1) permit more efficient reallocation of idle NC equipment, (2) establish a central postprocessor index, (3) establish the capability to assist military activities in work-loading their NC machines, (4) enable DOD to determine NC machining capabilities of each field activity, (5) promote sharing of maintenance data between activities, and (6) promote sharing of parts. However, the use of the expanded data base will apparently be entirely voluntary among the activities.

--DOD's Manufacturing Technology Group's Computer-Aided Design/Computer-Aided Manufacturing Subcommittee. The subcommittee is made up of representatives from the National Aeronautics and Space Administration, the National Bureau of Standards, the Defense Industrial Plant Equipment Center, the Army, the Navy, and the Air Force. Subjects covered extend beyond numerical control and into fields such as robotics, computer-aided design, shop loading and control, and group technology. In addition to being a cooperative information exchange, the subcommittee also functions to avoid duplication of effort and to study areas of common interest. Industry participation

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is encouraged and advanced Computer-Aided Design/ Computer-Aided Manufacturing techniques are presented by suppliers.

--Air Force Logistics Command. The command has issued a detailed instruction for all Air Logistics Centers covering NC applications; economic analyses and justifications; workmix studies; NC options; cost comparisons of NC equipment versus conventional machining; part programing; software; engineering, planning and programing documentation; tooling fixtures and gages; utilization reporting; personnel and training; preventive/corrective maintenance; performance records; prestockage of manufacturing material for numerical control; and retrofitting. The command has also established a centralized computer system, with terminals and minicomputers at all centers for programing and for centralizing tool inventories and spare parts stockage for NC machines. As in the past, the command continues to have full-time personnel to assist the overall management of NC.

--Naval Sea Systems Command. The command has drafted and is circulating a policy directive entitled "NC Program for Naval Shipyards," which addresses the procurement, use, and management of equipment; NC coordinators' responsibilities; exchange of data packages between activities; and the training of personnel associated with NC machinery. In addition, the command has recently tasked the Long Beach Naval Shipyard to develop an NC coordinator course and has contracted with the University of Illinois to develop a system which will determine when equipment should be replaced.

--Naval Aviation Logistics Center. The center continues to have an NC program manager who works with coordinators at each rework facility and sponsors Numerical Control/Computer-Aided Manufacturing workshops for the purposes of defining and resolving problems and exchanging technical information and ideas. A Numerical Control/Computer-Aided Manufacturing workshop was held in October 1975; however, another workshop was not held until March 1978. Correspondence indicated that the latest workshop had been held because of significant advances in technology and because DOD manufacturing trends require increased production and improved quality with decreased costs; these trends necessitate maximizing the benefits available from using Numerical Control/Computer-Aided Manufacturing.

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--Army Materiel Development and Readiness Command. This command furnishes overall policy guidance to subordinate commands, two of which manage the Army depots and arsenals. At the time of our previous reports, the command had a NC action officer who worked with activities having NC equipment. However, the position was vacated several years ago and during reorganizations the position was abolished. According to command officials, NC equipment is now considered an integrated part of shop operations and does not require the management emphasis that it once did.

--Army Armament Materiel Readiness Command. This command, which is responsible for arsenals, has no special management procedures for NC equipment because it believes that equipment management is the responsibility of arsenals.

--Army Depot Systems Command. This command has initiated a depot-wide study of numerical control to be directed from the Sacramento Army Depot. A representative of each depot has been designated to assist. The study will look into areas discussed in our prior reports and, although the parameters of the study have not been refined, draft plans for the study state that its purpose is to:

> "* * * clarify and define the conditions of the problem, and to develop a method and system to enable all DESCOM depots to become aware of the importance of NC and CAM, and to assist in the acquisition and establishment of effective NC facilities."

In our opinion, neither the Defense Industrial Plant Equipment Center seminars nor the DOD Manufacturing Technology Group operate at a level to deal effectively with the issues in our prior reports.

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